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WEEKLY March 28 - April 3, 2015

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BATTLE SCARS
How war reshapes the face of the Earth

RECKONING UP
Economists ask for help to understand money

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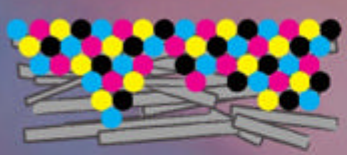

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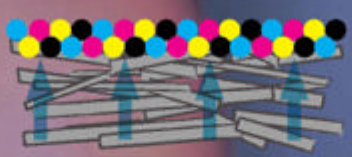

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CONTENTS

Volume 225 No 3014

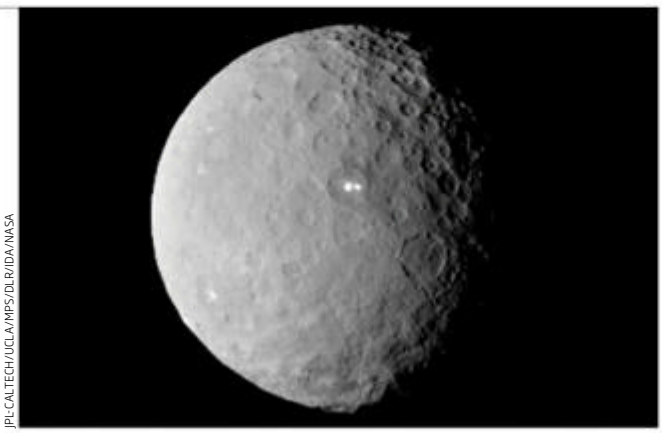
This issue online
newscientist.com/issue/3014

News

8

Little big planet

Our closest view yet of the monster of the asteroid belt



JPL-CALTECH/UCLA/MPS/DLR/IDA/NASA

On the cover

30

Know it all

The secrets of successful learning

Cover image
Eiko Ojala

Features

36

Battle scars

How war reshapes the face of Earth

DAVID KENNERLY/BETTMANN/CORBIS

Coming next week...

Special report: Belief
The strange ways we determine right and wrong

Photo finish
What's coming after the camera

Leader

News

Technology

Aperture

Opinion

Features

CultureLab

Regulars

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CONTACTS
Contact us
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Who's who
newscientist.com/people

General & media enquiries
enquiries@newscientist.com

Editorial
Tel 781 734 8770
news@newscientist.com
features@newscientist.com
opinion@newscientist.com

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VINCENT J. MUSI/NATIONAL GEOGRAPHIC CREATIVE

Thank god for civilisation

The idea that religion led to modernity is gaining strength

ABOUT 10,000 years ago, our ancestors began the greatest transformation in human history, abandoning the nomadic lifestyle that had long served them well in favour of permanent villages.

The origin of this "Neolithic revolution" is contentious. The answer once seemed clear: food. Farming was more efficient than foraging and so people gravitated towards it. Cities, writing and organised religion soon followed.

In recent years, though, this model has been challenged by archaeological discoveries. The most important is Göbekli Tepe in Turkey: a cluster of 11,000-year-old buildings with spectacular statues and other monumental architecture. The archaeologists who found it interpreted these as having a ceremonial purpose: a "cathedral on a hill", as one put it.

Yet the people who built them were nomads, not farmers. So the radical suggestion now is that it was not agriculture that drove the revolution, but religion. Some archaeologists oppose this idea, arguing that the ruins could have been domestic buildings, or were once surrounded by dwellings that did not survive. But the ceremony-first model is in the ascendancy, supported by further evidence unearthed in the Levant.

Now comes news that another ancient civilisation – the Maya – may also have had spiritual roots. Their oldest city, Ceibal, seems to have begun as a place where hunter-gatherers assembled for religious festivals (see page 12).

The parallels are intriguing. Maya civilisation developed in geographical isolation from the Old World, and several thousand years later. If it followed the same path, perhaps that tells us something profound about human cultural evolution.

Some secularists dislike the idea that spiritual needs drove the rise of civilisation. They fret that it will reinforce or restore religion's central place in society. But just because spirituality may have led to civilisation, it doesn't follow that it should lead it now. If religion did have an early founding role, we must acknowledge this, learn from it – and move on. ■

Fifth rock from the sun?

WHAT makes a planet a planet? It's nearly 10 years since the International Astronomical Union created a stir by agreeing a new classification system that kicked Pluto out of the club, demoting it to dwarf planet status.

In the intervening years it has become abundantly clear that the solar system's smaller bodies are at least as interesting as those that still enjoy full planetary status. We already think that the moons of Jupiter and Saturn are among the best places to search for alien life. Now, as spacecraft begin to map Pluto and its smaller cousin Ceres, dwarf planets are entering the limelight.

Is another round of planetary hokey-cokey on the cards? The leader of the Dawn mission is on record as saying that Ceres will turn out to be "every bit a planet as its terrestrial neighbours Mars, Earth, Venus and Mercury" (see page 8). If Ceres is a planet, so are Pluto, Eris and many others.

It doesn't really matter. In fact, reviving the debate will only detract from the excitement of exploration. Pluto's demotion was keenly felt by a generation of astronomers, both professional and amateur. Ceres has no comparable emotional pull, and nothing to gain from being promoted to planetary status. ■


NASA/BILL INGALLS

My twin is staying on Earth

Longest ISS stay begins

MAKE yourself at home. Two astronauts are set to get extra comfy on the International Space Station when they launch on Friday for the ISS's first ever year-long mission, double the length of the normal stay. The mission will help the US and Russia study the long-term effects of space flight, which is essential if humans are ever to fly to Mars.

NASA's Scott Kelly will join Mikhail Kornienko and Gennady Padalka, from Russia's space agency Roscosmos, on a Soyuz spacecraft due to launch on 28 March from Baikonur Cosmodrome in Kazakhstan. Kelly and Kornienko will spend a year on the station.

Serendipitously, Kelly has an identical twin brother, Mark, who is also an astronaut but will spend this year on the ground. NASA will compare data on the twins' health to try to distinguish the effects of space flight from those of genetics.

Thanks to Einstein's theory of relativity, which says a traveller in a fast-moving spacecraft ages less than someone on Earth, Scott Kelly will return about 10 milliseconds younger than Mark at the end of the year – although the difference is too small to measure.

Kelly and Kornienko won't beat the record for the longest single space flight. That is held by Valeri Polyakov, who spent nearly 440 days on board the Mir space station in the 1990s. But researchers studying the astronauts will make use of modern techniques such as microbiome analysis that weren't available during Polyakov's flight.

Tact hits Ebola fight

THE Ebola epidemic is a year old. Assessments of what allowed the outbreak to spin out of control in Guinea, Liberia and Sierra Leone are now trickling in.

Reports have revealed a picture of a crippled international health system that the World Health Organization (WHO) has neither the means nor the power to lead.

"The WHO thought declaring an emergency would damage relations with affected countries"

In a report published on Monday, aid group Médecins Sans Frontières says it warned on 31 March last year that the Ebola outbreak was "unprecedented" in its scale – only for the WHO to contradict it. The WHO appears to have been trying to avoid alienating affected countries because it needed their cooperation to tackle the outbreak.

An investigation by press agency AP criticised the WHO for not declaring a Public Health Emergency of International Concern earlier than August. Leaked WHO internal reports show it knew in mid-April that known cases were the "tip of an iceberg".

Declaring an international emergency was suggested in early June. However, a leaked email from Sylvie Briand, the WHO's head of epidemics, said this would not help control the outbreak because it could damage relations with affected countries.

Another leaked document said that Guinea wanted to understate the number of cases to reassure expatriates.

Martian fat

IS there lard on Mars? NASA's Curiosity Rover has detected what may be a fatty acid molecule in the soil of the Red Planet, although it is not clear whether it is biological in origin.

The find was presented by David Glavin, who works on the rover's SAM instrument, at the Lunar and Planetary Science Conference in The Woodlands, Texas, last week.

SAM analyses gases released by heating samples of rock, and the results are interpreted by matching the data to compounds analysed on Earth.

One SAM reading seems to relate to a type of fatty acid molecule. These are important for life because organisms use them to build cell membranes, but they could have a non-biological origin.

Glavin also confirmed previous hints from SAM of an organic compound called chlorobenzene. Again, this might not be a sign of life, but it suggests that complex organic molecules can survive on the surface of Mars, upping the chances of future missions finding microbes if they are there.


GORDON SCAMMELL/LOOP IMAGES/CORBIS

More regal than a car park

Return of the king

THERE have not been scenes like it in the UK since the burial of Diana, Princess of Wales. Thousands of people turned out in Leicester on Sunday to witness the passing of the coffin carrying Richard III, the English king who died on Bosworth Field on 22 August 1485.

How could they be so sure it was him? In 2012, archaeologists from the University of Leicester announced they had found a man's deformed skeleton under a

car park at the ruins of Grey Friars church, the last known resting place of Richard III. DNA and other evidence made a strong case, but the skeleton's Y chromosome does not match that of any living male descendant of the family.

"We took that into account in the statistical analysis," said Mark Thomas, a geneticist at University College London. He said it was likely that infidelity had broken the male line of descent. "There is a 0.0003 per cent chance that it's not him – and wars have been started over less – but it is within the margins of reasonable error to conclude that this is Richard III."

Iceland sequenced

THE floe of genetic information is still being surfed by Iceland. An epic sequencing project has found a gene linked to Alzheimer's and discovered that 8 per cent of the population there has at least one gene that doesn't work.

Published this week, the findings are the latest output from deCODE Genetics, a company based in the Icelandic capital Reykjavík that has been combing the nation's medical records and DNA looking for genetic differences linked to disease.

The work draws on complete genetic sequences from 2636 Icelanders – the largest analysis yet of individual entire genomes. Any differences identified were corroborated by comparing them with less-extensive genetic data from 104,220 Icelanders (*Nature Genetics*, DOI: 10.1038/ng.3247).

Kári Stefánsson of deCODE says the number of entire genomes should rise to 20,000 by 2016, with less detailed genetic data collected from 150,000 people – almost half the population.

The effort has not been without controversy, having started on the premise that all Icelanders were happy for their records to be used.

Secret science

SHHHH... A bill passed in the House of Representatives in Washington DC last week will either bust open the cosy cartel of science policy-makers at the Environmental Protection Agency (EPA), or dash government efforts to keep us safe from polluters – depending on your view.

The Secret Science Reform Act, pushed through by the Republicans and supported by industry groups, would prevent the EPA from issuing regulations on the basis of information that has not been made public – "secret science". But opponents say this would effectively dilute the EPA's power by limiting the research it can draw on.

"The US Congress is carrying out a sneak attack on science," says Andrew Rosenberg, of the Union of Concerned Scientists in Cambridge, Massachusetts. "The science community should be up in arms about these actions – but so should anyone who cares about using the best science to make good public policy."

The bill will need President Obama's approval, though. His office said earlier this month that he would be advised to veto it because the bill could "impede EPA's reliance on the best available science".

Solar eclipse tests German grid

THE sun went out, but the lights stayed on. Last week's partial solar eclipse in Europe provided an ideal stress test for the world's most solar-powered country, Germany, and so for the future of solar power itself.

Germany gets around a quarter of its power from solar and wind. But as solar power output varies with the intensity of sunshine, grid operators must use other power sources to balance out any fluctuations or risk blackouts and power surges. Their biggest challenge is rapid fluctuation in supply – just what the eclipse caused when it partly blotted out sunlight, then restored it three times faster than happens when the sun rises, says Volcker Quashning of the University of Applied Sciences in Berlin. To cope, German utilities doubled staff numbers on eclipse day. The country also cut electricity demand by turning off four power-hungry aluminium plants.

As the eclipse waxed and waned, output from Germany's 38.2 gigawatts of photovoltaic capacity dropped 15 GW, then climbed back. Operators compensated with power from hydroelectric and gas-fired plants. No problems were reported, either in Germany or with the 51 GW of solar in the rest of Europe.

The challenge could become a daily one by 2030, when Germany plans to have 66 GW of solar capacity, says grid operator Ecofys. A clear sunrise will then boost output as steeply as the end of the eclipse.

OLAV JONNESVOLD/EPA

Now that's a power cut

60 SECONDS

Get real on climate

Deny global warming and you don't get your money. That's the message from the US Federal Emergency Management Agency, which from next March will only give funds to states whose governors approve hazard-mitigation plans that address climate change.

Name that crater

Fancy naming part of Pluto? NASA's New Horizons probe will start mapping the dwarf planet in July, and the mission team want your help. They are inviting the public to submit suggestions for newfound craters and other features, and then vote on the most popular. Leading the pack so far are "Star Wars", "Tardis" and "J. R. R. Tolkien".

100 per cent green

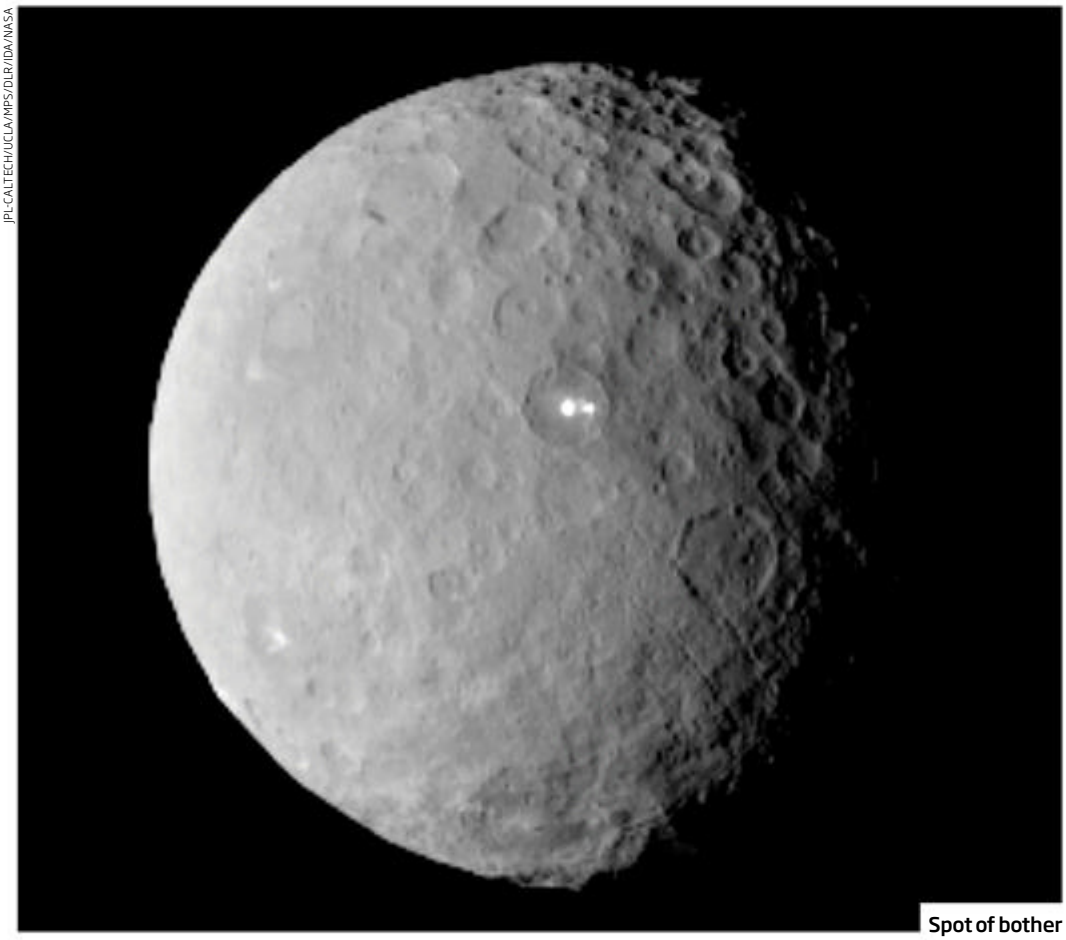
Costa Rica did not use a drop of fossil fuel to power itself during the first 75 days of 2015. The country gets most of its energy from hydropower, which has been going strong since January thanks to heavy rains.

Spray with care

Mind that weedkiller. Glyphosate, the world's most widely used herbicide, has been classed as "probably carcinogenic" by the International Agency for Research on Cancer in Lyon, France. The agency cites links to various rare cancers including non-Hodgkin lymphoma (*The Lancet Oncology*, DOI: 10.1016/S1470-2045(15)70134-8).

Up in a flash

Hit the light. Male rats have been engineered to develop erections when their genitals are illuminated with a blue lamp, often used to treat seasonal affective disorder. The lamp even made some rats ejaculate (*Angewandte Chemie*, doi.org/f26psr). The team hopes the method will provide an alternative treatment for men with erectile dysfunction who don't respond to drugs like Viagra.



JPL-CALTECH/UCLA/MPS/DLR/IDA/NASA

Spot of bother

New dawn for Ceres

Jacob Aron takes a look inside Ceres, the comet-planet hybrid that might just harbour life in the asteroid belt

CERES is a dwarf planet with giant potential. As NASA's Dawn spacecraft gears up for the first in-depth look at this tiny world, speculation is rife. Could Ceres be an overgrown comet? Host an ocean made of mud? Or even possess icy volcanoes that make it an unexpected host for life in the asteroid belt?

"When we complete our observations, we will show that Ceres is every bit a planet as its terrestrial neighbours Mars, Earth, Venus and Mercury." That's what Christopher Russell, who leads the Dawn mission, told the Lunar and Planetary Science Conference (LPSC) in The Woodlands, Texas, last week.

The first signs of excitement came earlier this month when Dawn spotted a mysterious bright spot just 1 pixel wide inside a crater as it pulled into orbit around the dwarf planet. There were suspicions that the spot could be a sign of water spewing into space, and now fresh views, presented for the first time at the LPSC, lend weight to the idea.

In Dawn's latest pictures, the bright spot is visible even from the side, meaning it probably protrudes above the crater. "What is amazing is you can see this feature while the rim is very likely in front of the line of sight," said Andreas Nathues, who is in charge of the mission's camera. "We believe this could be some kind of outgassing."

Remote observations using the Herschel space telescope show Ceres spitting water from somewhere on its surface, probably towards the equator. We think other icy bodies in the solar system, like Jupiter's moon Europa and Saturn's moon Enceladus, spew water in spectacular plumes from subsurface oceans (see diagram, right). If Ceres also has a buried sea, that could boost its chances of playing host to life – so astronomers are keen to track the plumes to their source.

"Ceres could be producing comet-like emissions driven by a weak cryovolcano"

Images taken from dusk until dawn on Ceres seem to indicate something more transient, since the spot brightens throughout the day and completely disappears at night. So the patch could be a pocket of ice on the surface that releases gas as it warms up in the sun, which is similar to how a comet behaves. However, Nathues said only higher resolution data will confirm its true nature. This won't come for a while, as Dawn is on the dark side of Ceres and won't emerge until mid-April.

But a model of Ceres presented at the LPSC added a complication, suggesting comet-like behaviour is only possible at the dwarf planet's poles, not the lower latitudes where the bright spot has been seen.

Timothy Titus of the US Geological Survey in Flagstaff, Arizona, presented a thermal model that considered where ice could remain stable on Ceres's surface over the lifetime of the solar system, rather than boiling away more quickly. If Ceres is behaving like a comet, it must have ice patches that can survive for a long time until the sun's heat reaches them as the dwarf planet moves into a warmer part of its orbit.

Titus found that long-lasting ice could only be possible in chilly latitudes above 40°. But the plumes spotted by Herschel seemed to come from nearer the equator. "The water ice is just not stable at the latitudes that the plumes are supposedly coming from," Titus says.

What about cryovolcanism? In this scenario, ice and water are ejected from the surface by processes similar to those that drive magma volcanoes on Earth. Ceres doesn't have enough muscle to drive these eruptions, according to a second model presented at the LPSC by David O'Brien of the Planetary Science Institute in Tucson, Arizona.

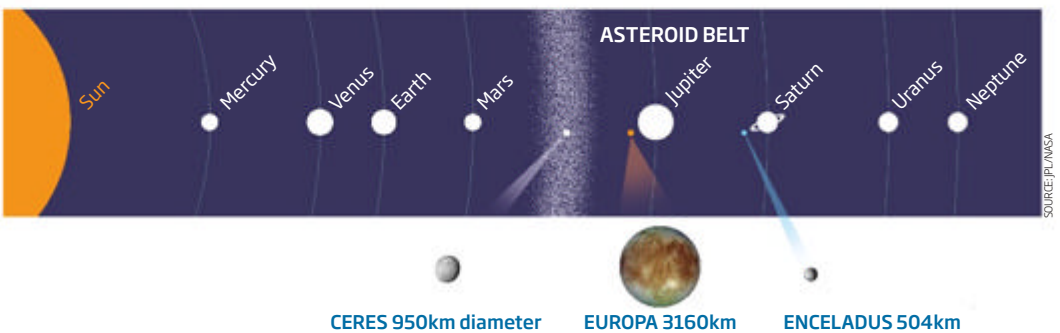
Let's suppose that Ceres has a subsurface ocean covered by an icy shell. As the bottom of the shell freezes, it expands, putting pressure on the ocean and the shell itself. To create a cryovolcano, says O'Brien, the water pressure has to build up enough to shoot up through the shell before the ice cracks and relieves the pressure.

Since we don't know exactly how deep the ice is on Ceres, O'Brien modelled a range of plausible depths. None recreated the conditions for spewing cryovolcanoes – the ice always cracked before enough pressure accumulated. In the best-case scenario, water reached about 90 per cent of the way to the surface.

Intriguingly, that might mean water could reach the surface from a deep crater, where there would be less ice to negotiate – perhaps even from a crater like the one where Dawn saw the bright spot. "Everybody wants to know what's going on there," says O'Brien. A cryovolcano could be producing enough of a plume to replenish the ice on the surface. So Ceres could be producing comet-like emissions, driven by a weak cryovolcano. "It's sort of a midpoint between comets and cryovolcanic icy worlds," says Titus.

Water, water everywhere

Small bodies all over the solar system are spitting liquid into space, possibly from subsurface oceans or lakes



SOURCE: JPL/NASA

There is more than one way to make a cryovolcano, though. Some models suggest the core of Ceres may be heated by radioactive isotopes left over from the dwarf planet's formation. These could provide enough energy for punchier volcanism, perhaps producing larger plumes – and heat would be beneficial for any bacteria lurking below the surface.

"Any place you've got the potential for liquid water, you've got potential for life. Ceres could be a target"

"Any place you've got the potential for liquid water, you've got the potential for life," says Titus. "Ceres could be an extremely exciting astrobiological target."

Even if water isn't making it to the surface, cracks in the ice shell could give Dawn a way of looking deeper within Ceres. If there are gases dissolved in the ocean, cracks could release them for the spacecraft to sample, says O'Brien. "It's like shaking up and opening a soda bottle."

And there may be more than water there. Bryan Travis, also of the Planetary Society Institute, presented a model of Ceres's interior that started out as a mix of ice and silicates, the minerals that make up the majority of Earth's crust. Then the mix separated into a silicate core and an ice shell, with a mud ocean sandwiched between the two. Dawn won't necessarily be able to see such mud directly, but Thomas Davison of Imperial College London has a way to distinguish between a mud and water ocean (see "Questions for Dawn", left).

All of this is to come when Dawn swings back to the day side of Ceres next month. Researchers have already decided to base the names of regions on the surface, such as Yumyum, after harvest deities, but just what they'll find there remains a mystery. "We really don't know what to expect for Ceres," says O'Brien. "It's pretty much bound to surprise us." ■

QUESTIONS FOR DAWN

Is Ceres a jumped-up comet or a failed planet?
We think that comets are the building blocks left over from the formation of the rocky planets in our solar system. Ceres, the only dwarf planet in the inner solar system, may have failed to gather enough building blocks to become a proper planet, leaving it somewhere in-between.

Does Ceres have an ocean?
Remote measurements of the dwarf planet's density suggest it has a rocky core coated in an icy shell, but it's still unclear whether liquid water lurks beneath the two. Even if Dawn doesn't spot water at the surface, it might find other indicators, like patches of salty material left behind by water that has boiled away. Such signs can confirm the presence of an ocean.

Is it water or mud?
To figure out whether the internal liquid is water or something sludgier, Dawn will have to take note of Ceres's gravitational field. Asteroid impacts deform Ceres's core, changing its internal density and thus its gravitational pull. Mud would dampen this effect, so as Dawn flies over Ceres, differences in its pull could reveal deformation in its core and in turn what kind of ocean it has.

NASA/JPL-CALTECH/SCIENCE PHOTO LIBRARY

Why is Ceres different from Vesta?
Before reaching Ceres, Dawn spent a year hanging out at Vesta, the second largest object in the asteroid belt. Vesta isn't round and has no water, but both objects are thought to be examples of the stuff that formed planets like Earth. One of Dawn's goals is to figure out why these two bodies are so different, and how others like them built the rest of the inner solar system.

Is there life on Ceres?
Dawn is not equipped to detect life directly, but it can search for signs of habitability, such as an ocean. It could also identify whether Ceres is heated internally by radioactive isotopes by looking for patches of cryovolcanoes on the surface. Both liquid water and heat raise the chances for life.

Pork chop… with a side of superbugs

Debora MacKenzie

IT HAS been called an apocalyptic threat, and our hunger for meat will only make it worse. The world's farmers are feeding an estimated 63,000 tonnes of antibiotics to chickens, pigs and cattle every year, encouraging the evolution of resistant bacteria, which have repeatedly been linked to human infections.

The team behind the estimate – the first of its kind – also forecasts that antibiotic use will climb by 67 per cent to 106,000 tonnes by 2030. Most of the increase is expected to be in middle-income countries, but once resistant bacteria appear, they can spread around the world.

The problem is worsening as people prosper and can afford to eat more meat and dairy. Such is the demand that, according to team member Tim Robinson of the International Livestock Research Institute in Nairobi, Kenya, the total biomass of the world's livestock now outstrips that of people.

Traditionally, livestock have foraged for grass or scraps in pastures or alleys between houses. But producers worldwide are increasingly switching to intensive production with animals fed in crowded barns, as already happens in rich countries. Even if the animals are not sick, the feed routinely contains low doses of antibiotics to make them gain more weight per unit of food eaten, boosting slender profits.

Livestock accounts for some 80 per cent of the antibiotics consumed in the US, but there are no corresponding figures for global consumption. To fill this gap, Robinson's team looked at the amount of antibiotics farmers in rich countries feed to intensively reared livestock. Then they mapped pig, chicken and cattle populations worldwide, noting the proportions that are raised intensively, and how those are predicted to grow over the next decades.

"Feed routinely contains low doses of antiobiotics to make animals gain more weight and boost profits"

With these details, the team's computer model could calculate the antibiotics consumed by livestock in every country.

China is the worst offender: its livestock get through 15,000 tonnes a year, 50 per cent more than the US, the next on the list. Surprisingly, Germany comes fourth despite a 2006 European Union ban on antibiotic growth promoters.

China's consumption is set to double by 2030, along with that of India, Brazil and South Africa. In countries such as Indonesia, Nigeria and Peru, it will more than double (*PNAS*, doi.org/242). And these estimates are likely to be conservative, says Robinson, due to simplifications in the model.

Frank Aarestrup of the Technical University of Denmark in Lyngby, who raised the alarm about antibiotics in livestock in the 1990s, welcomes the figures even if they are an underestimate: "It gives us something to argue from." He adds that the question now is whether these countries will follow the US example or Denmark's, which has eliminated the use of antibiotic growth promoters. "That's going to be a challenge," says Robinson. ■

DANIEL ACKER/BLOOMBERG VIA GETTY IMAGES

Healthy, but storing up trouble

Arctic winter ice cover plunges to record low

POLAR bears take note. There was less Arctic sea ice this winter than in any year since records began, bringing the scary prospect of an ice-free Arctic a step closer.

Summer ice has hit a series of record lows in recent years as the Arctic has warmed by almost 2 °C, twice as fast as the mid-latitudes. The ice builds up again each winter and the average extent of winter ice has been declining less steeply, although it has been getting thinner.

However, this year's winter refreeze was the weakest since satellite observations began in 1979, according to provisional data from the National Snow and Ice Data Center at the University of Colorado in Boulder. Its peak of 14.5 million square kilometres, reached on 25 February, was around 1 per cent lower than the previous worst, recorded in 2011.

NSIDC researchers are wary of blaming global warming, pointing out that there is a lot of natural variability in ice cover. The unusual path of the jet stream – a high-altitude wind that affects weather – this winter warmed the Pacific side of the Arctic, reducing Bering Sea ice in particular. The ice build-up was also cut short this year because the spring melt began two weeks earlier than usual.

However, Jason Box of the Geological Survey of Denmark and Greenland in Copenhagen says the Arctic is changing profoundly. "We are already in uncharted territory," he says. "Models are all understating the Arctic response to climate change." Fred Pearce ■

PAUL SOUDERS/CORBIS

Vanishing act

9/11 firefighters hit by autoimmune diseases

THE attack on the World Trade Center changed the world 13 years ago. We're now beginning to understand the long-lasting impact it had on the health of emergency workers who cleared up the site.

Nearly 16,000 firefighters and other emergency crew worked on the site over a period of 10 months after the attack. As well as higher rates of cancer and respiratory problems, it now seems these people are more likely to suffer from autoimmune diseases, such as rheumatoid arthritis and lupus.

When the twin towers fell in 2001, they created an enormous amount of airborne dust that included pulverised cement, glass, silica, asbestos, lead and dioxins. Fires continued to burn for three months afterwards.

"Unlike ordinary building sites, there were unprecedented amounts of aerosolised dust and fumes," says Mayris Webber of the Albert Einstein College of Medicine in New York. Face masks and respirators were available, but there was not always enough to go round, and some people didn't like using them for long periods, says Webber. "They were not consistently worn."

The health problems soon began. More than 70 per cent of firefighters developed a breathing problem in the first year, from coughing to asthma. Since then, they have also been diagnosed with higher than average rates of certain cancers.

Some of the chemicals in the World Trade Center dust have been linked with autoimmune diseases, so Webber's team decided to look for evidence in the workers' health records, kept as part of the fire department's monitoring programme.

"Unlike ordinary building sites, there were unprecedented amounts of dust and fumes"

Although the number was small – only 216 self-reported cases – Webber points out that you would normally expect very low rates of autoimmune disease in this group of particularly fit and healthy people. So instead of comparing the firefighters with average New Yorkers, they analysed 59 medically confirmed cases alongside firefighters in the monitoring programme who had not developed any autoimmune disorders.

They found that those affected were likely to have worked on the site for longer. The rate of cases was three times higher in those who worked for the full 10 months than in who stayed only one month. On average it took five years to develop the disease.

The workers were exposed to such a complex mix of chemicals it may not be possible to identify the culprits. However, we know that breathing compounds such as asbestos and silica into the lungs seems to make the immune system more reactive, says Jean Pfau of Idaho State University.

Publicising the effects of these chemicals on workers at the world's most famous demolition site could help those in the construction industry. They often come in contact with materials like silica so should be more aware of the dangers and the need for protective gear. "This is a powerful paper describing the phenomenon," says Pfau. **Clare Wilson** ■

ANGEL FRANCO/THE NEW YORK TIMES/REDUX/EYEVINE

Danger: cancer-causing dust

Martian ice melt is not a sign of climate change

GLOBAL warming isn't happening on Mars, so face up to it on Earth. That's the conclusion of an analysis of the Red Planet's melting polar ice cap, which shows that Swiss-cheese-like pits forming in the ice are part of a natural cycle, not unusual warming.

The pits were first spotted at the carbon dioxide ice cap at the Martian south pole in 1999, then pictured again in 2001, one Martian year later. Comparing the images revealed the pits had grown by a few metres. At that rate, the entire ice cap would disappear in a few thousand years.

Some climate sceptics suggested this meant our neighbouring planet is undergoing global warming just like Earth, so the sun – not humans – must be behind warming on both planets.

Now Shane Byrne at the University of Arizona and his colleagues say the pit size changes naturally every 100 years or so. He used images of the south pole from NASA's Mars Reconnaissance Orbiter to track changes in the pits over four Martian years and create a model of their formation. This showed that thin CO_2 ice starts out smooth, but as gas freezes onto it, some places end up lumpier. The areas with the highest slopes absorb more sunlight, eventually melting to create the pits.

The pits' walls absorb even more sunlight, which makes them grow. Left unchecked this would eat away the entire ice cap. But CO_2 snow can fill in the pits, smoothing out the ice and starting the process over again. Byrne presented the model at the Lunar and Planetary Science Conference in The Woodlands, Texas, on 16 March.

"When the expansion of these pits was first noticed, people immediately said it must be climate change," he says. "You can easily explain all of this without having to invoke any of that."

Depending on the size of the pits, this cycle can last centuries, which explains why we haven't seen it – we haven't been watching long enough. Jacob Aron ■

SEBASTIAN HOMBERGER

Build it and they will come

Festivals sparked first Maya cities

Fred Pearce

THE great Central American jungle civilisation of the Maya is renowned for its stepped pyramids, temples and great urban plazas, where human sacrifice may have been routine. But a surprising story is emerging from detailed examination of archaeological remains. One of the Maya's oldest known great cities, at Ceibal in Guatemala, began as a multicultural love-in.

The first great pyramid builders of Central America, it turns out, were mostly travellers: hunters and gatherers of no fixed abode, who began meeting for ad hoc ceremonies and rituals in the jungle about 3000 years ago.

The findings overturn conventional thinking that ancient cities all emerged from prosperous farming communities, and that big religious ceremonial complexes were only built in the most successful cities.

In the case of the Maya, and some Middle Eastern cultures, it was the other way round. The first builders and worshippers were more new-age hippy festivalgoers than yeoman farmers or urban sophisticates. Only hundreds of years later did their successors settle, take up full-time farming and build a city.

For the past decade, Takeshi Inomata of the University of Arizona in Tucson has been excavating the Ceibal site on the banks of the Pasión river, which once had some 10,000 inhabitants and sprawled over tens of square kilometres. His team's latest investigations reveal that the city's residential areas are much more recent than the first ceremonial pyramids and temples (*PNAS*, doi.org/25g).

Early builders

"The ceremonial complex was the first architecture built at Ceibal," Inomata says. "Durable residences were not built until two to six centuries later."

The first builders, in about 950 BC, were hunters, fishers, foragers and nomadic farmers, who gathered periodically for the construction of ceremonial buildings and community rituals. While at work, they lived in temporary shelters before dispersing again.

Even 250 years later, when the largest pyramids and temples were completed, only a small elite lived in permanent homes. The rest came and went. Only in about 300 BC did urban living become the norm, with the spread of suburbs full of houses built on permanent platforms.

Festival city

An ancient collection of diverse hunter-gatherers came together to build religious festival sites that may have been the origin of big Maya cities

Inomata suggests that the collective activity of building temples and worshipping eventually encouraged integration of the diverse traveller groups and the growth of an urban centre, rather than the other way round.

"Before the pyramids dripped with the blood of human sacrifice, this was a cultural melting pot"

Inomata and his wife Daniela Triadan have previously shown that Ceibal was not just the first citadel of the Maya, but probably the earliest of many ceremonial complexes built in the Central American jungles over the past three millennia.

Some researchers will take more persuading that Ceibal was built by nomads, though. Elizabeth Graham of University College London says that permanent wood-built structures may have predated the masonry uncovered by Inomata's team but failed to survive the ravages of nature.

"We have to be careful not to fall into the trap of linking sedentism to masonry construction," she says. But she likes the idea that collaborative construction played an important role in social integration.

At the height of the Maya civilisation, society was strongly hierarchical. It is thought that there were brutal religious rituals run by priest-kings, with human sacrifices, bloodletting and self-mutilation aimed at placating their gods. However, the extent of those is still debated.

But the story now emerging is that Ceibal was very different in the early days, says Melissa Burham, a co-author of the new study.

"Different peoples with diverse ways of life coexisted in apparent harmony for generations before establishing a uniform society," she says. Before the steps of the pyramids dripped with the blood of human sacrifice, Burham adds, Ceibal began as "an ancient cultural melting pot". ■

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NewScientist

Black holes both gobble and nibble

Jacob Aron

IT'S like a buffet where no one agrees on table manners. When a black hole encounters a star, it seems there is more than one way for this cosmic enigma to chow down.

Stars can safely orbit a black hole if they keep their distance, but if they cross a line called the Roche limit, they get torn apart in a so-called tidal disruption event (TDE). This is when the black hole loads up its plate by stretching the star in one direction and squeezing it in the other, gradually distributing hot gas from the star in a disc around itself. Once it has finished the task, the black hole can gorge on the star's remains until nothing is left.

Normally, forming the disc and eating it both take years, but Pablo Laguna of the Georgia Institute of Technology in Atlanta and his colleagues have discovered that some black holes positively race through these stages (arxiv.org/abs/1502.05740).

The team simulated what happens when a black hole a million times the mass of the sun encounters a sunlike star at close range – so close that they are almost touching.

In this situation, the star's orbit twists slightly as it rotates, due to an effect called relativistic precession. Now the black hole can load its plate in an instant, tearing the star apart and spreading it out into a disc in a couple of minutes. "The precession effect helps to spread the debris and wrap it around the black hole," Laguna says. The black hole then takes a few days to swallow the star.

Meanwhile, another team has spotted what appears to be a black hole eating at a snail's pace, returning to the star just once a decade to load up a single spoon. Deborah Mainetti of the University of Milano-Bicocca in Milan, Italy, and her colleagues used data from three space telescopes to track a galaxy called IC 3599, around 300 million light years from Earth.

In the 1990s, a German space telescope called Rosat saw the galaxy flaring up. The way it faded matched a traditional TDE, so could have been caused by a central black hole ripping up a star. But the flaring was also much less bright than expected, making some doubt whether it really was a black hole mid-meal.

XPACIFICA/REDUX/EYEVINE

A stellar spread?

NASA's Chandra space telescope saw a brief flare in 2002, and NASA's Swift has seen more in recent years. Together, the observations suggest that IC 3599 experiences a TDE-like event every nine and a half years, says Mainetti (arxiv.org/abs/1502.07184).

"If this was a disruption of three different stars, we wouldn't have seen such a similarity," she says. That means it must be the same star on a very eccentric orbit, passing just close enough once a decade for the black hole to have a little taste – a process Mainetti calls spoon-feeding. At this rate, it could take 10,000 years to consume the entire star.

Spoon-feeding could unmask black holes that wouldn't otherwise reveal themselves, says Mainetti. "This is a very important way to observe black holes that are generally quiescent." ■

Antibody slows Alzheimer's mental decline

AT LAST, a ray of hope for people with Alzheimer's disease. In a field where almost all clinical trials of new drugs fail, a drug called aducanumab appears to be bucking the trend.

In a small trial, the drug slowed the progression of the disease and reduced deposits of amyloid plaques, the substances blamed for damaging the brains of people with Alzheimer's.

This is the first time a drug has had a statistically significant effect on both cognition and amyloid in people with mild disease, says Alfred Sandrock at Biogen, the firm that developed aducanumab, based in Cambridge, Massachusetts.

The drug, an antibody discovered by screening blood from healthy older people and people whose Alzheimer's is stable, targets and clears amyloid proteins from the brain.

Of the 166 people in the trial, 54 received a placebo, with the rest divided into groups receiving different doses of the drug once every four weeks. Scans showed that there was virtually no change in the amount of plaque in the placebo recipients' brains. For people taking the antibody, the higher the dosage, the more plaque was cleared.

Likewise, patients' memory loss, judgement and other symptoms of cognitive decline deteriorated slower the more drug they received. "The cognitive benefits are unusually robust for a study of this size and duration," says Eric Karran of Alzheimer's Research UK.

"It's the first time a drug has had a proper effect on both cognition and the amount of plaque in people's brain"

But Karran warns the results should be treated with caution: several participants pulled out because of side effects or lack of perceived benefit, skewing the results towards success. Plus, other drugs that initially looked promising have gone on to fail in later trials, he says.

The firm, which presented its results at an Alzheimer's and Parkinson's disease conference in Nice, France, says that it now plans to carry out a much larger trial. Andy Coghlan ■


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Hollow marine monsters may use light signalling to dive

TALK about teamwork. Huge free-floating coalitions of marine invertebrates known as pyrosomes have to coordinate to ensure the colony heads the right way – and light may be their secret to doing so.

The tubular pyrosomes are made up of many clones called zooids. For the colony to feed and move, each zooid sucks in water from outside and blows it down the tube to form a rudimentary jet engine. Shutting off this propulsion system allows it to sink out of harm's way – but how does the signal pass through the colony when they lack any common nerves to communicate?

David Bennett at Bangor University, UK, found that when a pyrosome is brushed by an external object, it lights up like a Christmas tree. In unpublished research he suggests it is this signal that ripples through the zooid cells, telling them to cut their engines.

Pyrosomes are rarely seen, though, partly because we're not looking in the right places, says Mangesh Gauns of India's National Institute of Oceanography in Goa. He analysed conditions off the coast of India where a swarm was seen and found that pyrosomes need cyanobacteria small enough for the zooids to swallow along with the right mineral balance in the water (*Zoological Studies*, doi.org/23j). These conditions should be commonplace away from coastal waters, which are dominated by larger plankton that can block the zooids' filter-feeding system.

Wandering Jupiter paved way for Earth

IT CAME in like a wrecking ball. Jupiter may have ploughed through the early solar system, driving some of the first planets to a fiery death in the sun – and cleared room for planets like Earth.

Most other systems we've observed so far contain huge rocky "super Earths" that orbit very closely to their host star – even closer than Mercury is to our sun. By contrast, our system has four small rocky planets, Mercury, Venus, Earth and Mars, that all orbit much further from the sun.

New simulations suggest a wandering Jupiter could explain this. Konstantin Batygin at the California Institute of Technology in Pasadena and Greg Laughlin at the University of California, Santa Cruz, showed that Jupiter could have drifted inwards, pulled by gas swirling around the sun, to somewhere around where Mars sits today (*PNAS*, DOI: 10.1073/pnas.1423252112).

As it did, it would likely have pulled any nearby objects along for the ride. These would have then smashed into each other and spiralled into the sun.

Later, a push from another massive planet, Saturn, could have taken Jupiter further out again. The debris left over from all this would have formed the small rocky planets we know today.

Turbo termites threaten Florida

IT SOUNDS like a low-budget B-movie, but the two most destructive termite species have interbred to form a super-race.

The Formosan and Asian subterranean termites, native to east Asia, are now widespread invasive species, causing billions of dollars of damage annually. Their ranges rarely overlap, and where they do – such as in southern Florida – they have bred at different times of year.

But Thomas Chouvenc at the University of Florida in Fort Lauderdale noticed that breeding swarms had begun to form at the same time, with many cross-species pairs. What's more, these mixed pairs founded viable colonies in the lab – and churned out offspring twice as fast as the parent species (*PLOS One*, DOI: 10.1371/journal.pone.0120745).

"If it grows that fast, it can make damage that much faster, too," says Chouvenc.

Worms sniff out cancer in urine

DOGS do it. Mice do it. Even some people can do it. Now roundworms have been added to the list of creatures that can detect cancer. Those behind the discovery are working with technology firm Hitachi to turn the finding into a diagnostic test.

To see if *Caenorhabditis elegans* worms could diagnose cancer, a team led by Takaaki Hirotsu at Kyushu University in Fukuoka, Japan, placed the worms on Petri dishes dotted with spots of urine from 242 people, 24 of whom had cancer. The worms were attracted to the cancer samples, identifying them correctly 96 per cent of the time, a success rate that the researchers claim is greater than any cancer blood test (*PLOS One*, doi.org/24v).

The long reach of toxic cane toads

CANE toads are trouble – even more so than we thought. They poison their predators and this seems to affect other prey species down the line, with unknown consequences.

The toads were introduced from the Amazon in 1935 as a failed attempt to control a beetle that devastated sugar cane crops. Now there are hundreds of millions stretching from coast to coast.

Sean Doody at the University of Tennessee and his team tracked the invaders as they conquered new territory in Western Australia. They measured the populations of three species of water monitor lizard that eat the toads, and the crimson finch, which is also prey for the lizards. The toads wiped out about half of the water monitors within five years. That had a knock-on effect on the finches: the proportion of surviving fledglings jumped from 55 to 81 per cent (*Ecology*, doi.org/223).

The loss of predators is throwing the whole ecosystem out of balance, says team member Simon Clulow at the University of Newcastle in Australia. Toads are causing ripples throughout the ecosystem that are potentially far-reaching and not well understood, he says. For example, the higher number of birds may affect plants that the birds feed on, and other animals that eat those plants and so on.

REDBRICKSTOCK.COM/ALAMY

You can strike gold if you have a mine like a sewer

TO MAKE a little money, you might have to get your hands dirty. What we flush down the toilet could be a goldmine for anyone who finds the right way to process it.

When sewage reaches the treatment plant, chemicals and microorganisms are used to separate out some components like sugars and grease. About half of the remaining sludge becomes fertiliser, while the rest is incinerated or dumped in landfill.

But chemicals used in industrial mining could pull metals out of human waste streams, say Kathleen Smith of the US Geological Survey and her team. In a talk at the American Chemical Society meeting in Denver, Colorado, on 23 March, Smith presented the results of their attempts to do just this, using sewage from communities in the US Rocky Mountains.

There's good reason to think the approach could be profitable. Many household products, such as detergent and sunscreen, contain metal nanoparticles, and some plumbing can shed amounts of silver. Some alcoholic drinks even contain tiny gold flakes.

In their early work, the team did indeed find tiny amounts of gold – enough, they say, that it would be worth mining if present in rock at those levels.

That tallies with another study published earlier this year, by Paul Westerhoff at Arizona State University in Tempe. He found that the waste produced by a million Americans in a year would be worth about $13 million for its copper, iron, palladium and other metals (*Environmental Science & Technology*, doi.org/24w).

Brain training can focus the mind

WHAT were we talking about? Oh yes, brain training may help inattentive people focus on tasks in their daily life. At least, that's the implication of an analysis of one programme in particular.

Megan Spencer-Smith at Monash University in Melbourne, Australia, combined the results of 12 randomly controlled trials looking at the effects of Cogmed, which is designed to improve working memory. The studies all included a measure of the programme's impact on people's attentiveness in daily life, and all but one looked at children or adults who had problems such as attention deficit hyperactivity disorder.

Cogmed reduced inattention by an "effect size" of 0.47. Four months later, this had dropped to 0.33. In educational interventions, an effect size of 0.25 is deemed valuable, says Spencer-Smith. She describes the effect as "moderate to large" but questions if this is enough for something that has people training for 15 hours over five weeks. Susanne Jaeggi at the University of California, Irvine, says more studies are needed to draw firm conclusions (*PLoS ONE*, doi.org/24x).

ALAN COPSON/GETTY

Electric cars may help keep cities cool

COOL it. Swapping conventional cars for electric ones might help cities like Beijing beat the heat, and lower emissions of carbon dioxide by cutting down on air conditioning.

Manufacturing electric cars is still relatively costly and carbon-intensive. But as well as providing potentially carbon-free driving, electric cars emit almost 20 per cent less heat than conventional cars. This could lower city temperatures, meaning use of air conditioning would also drop, says a team led by Canbing Li from Michigan State University in East Lansing.

Using summer 2012 in the Chinese capital of Beijing as an example, the team estimates that replacing conventional cars with electric ones would reduce the heat by nearly 1 °C. That in turn would result in a reduction in air conditioning use, leading to a drop of 10,686 tonnes per day in carbon dioxide emissions (*Scientific Reports*, doi.org/23g).

"I was surprised by the level of decreased energy consumption of air conditioning," says Li. He says that although electric cars are more costly to build, unlike conventional cars that depend on fossil fuels, their disadvantages can be overcome.

Fighting flares

North Dakota's wasteful flares are finally being snuffed. **Jesse Emspak** finds out how oil companies are making wells cleaner and leaner

SEEN from space at night, the thinly populated state of North Dakota could be mistaken for a major metropolis. But the bright lights aren't the glow of streets and homes. They are flames from billions of litres of natural gas being burned, a by-product of the booming oil industry. Now, under pressure from regulators, technologies are emerging to help harness that wasted resource.

Economics drives the waste. Oil production from North Dakota's Bakken shale quadrupled between 2010 and 2014. The volume of gas that belches up with the oil followed in step, faster than oil companies could build infrastructure to pipe it away. Too impure to generate power on site, and too light for train cars to haul a worthwhile amount to market, the gas presented oil companies with an unprofitable problem. So they burned it.

"It was worth it to just put the gas up in smoke," says Joseph Palaia of Colorado oil technology company Pioneer Energy. He says the oil was 10 times more valuable than the gas that came with it, so capturing the gas didn't make business sense.

Now, as states adopt stricter emissions standards, that's starting to change. Energy companies and start-ups are finding ways to capture and make use of the gas, reducing carbon emissions and increasing efficiency.

The problem is huge. In 2014, about 26 per cent of gas produced in North Dakota was flared off – 10 million cubic metres of fuel a day, emitting about 21 tonnes of carbon dioxide. This is compared with the rest of the US, which only flares 1 per cent of its natural gas on average. But merely venting the gas would be worse than burning it, because its primary component, methane, traps heat in the atmosphere more effectively than CO_2.

In July 2014, North Dakota's Department of Mineral Resources took action, issuing a state order for the reduction of flare gas. California-based company Ener-Core has one solution to make use of the waste product. Its technique involves pressurising the gas, which forces it to start reacting with oxygen. This reaction produces heat, which is then used to drive a turbine and produce electricity.

"Without this technology, oil companies are burning money, and needlessly pumping out CO_2"

The system was originally designed to work with any source of waste gas, so Ener-Core is running its first flare-gas test facility at the University of California, Irvine. The company plans to sell units to oilfields in the next three years. The generators are designed to replace the diesel generators that oil rigs currently rely on to power their operations.

Pioneer has a different approach – a huge refrigerator, mounted on the back of a truck, which it calls a Mobile Alkane Gas Separator (MAGS). In this, flare gas is compressed and dehydrated, before being cooled and separated into its component hydrocarbons. The methane is used on site to generate electricity and the heavier hydrocarbons are shipped away for sale. Pioneer deployed its first MAGS unit in North Dakota last November.

General Electric has a similar system, a 12-metre trailer that compresses and separates gases. GE installed its system at a Bakken shale well run by Statoil last year. Statoil estimates the system captures between 80,000 and 140,000 cubic metres of flare gas a day. The produced methane is used to run trucks on site and Statoil says it has already commissioned a second unit for its Bakken operation.

Time is of the essence. Wells produce the most flare gas when they are new, says Chad Wocken, senior research manager at the Energy & Environmental Research Center at the University of North Dakota. For every new well without this technology, companies like Statoil are burning money, and needlessly pumping carbon dioxide into the atmosphere.

The technology for harnessing flare gas might be clever, but flaring would never have become a problem if regulation around the boom had been tighter.

"It's not a failure of technology, but of regulation," says David McCabe, an atmospheric scientist at the Clean Air Task Force in Boston. If the current rules had been in place from the beginning, oil companies would have had to build adequate pipeline capacity to ship the flare gas out.

They may have taken the long way round, but North Dakota's oil companies are finally reining in their wasteful behaviour. By 2016, the state aims to have cut the amount of flared gas down to 15 per cent. Soon, astronauts on the International Space Station should be able to stop mistaking the Bakken shale for a city. ■

JIM WILSON/NEW YORK TIMES/REDUX/EYEVINE

Enough already

MARK HUNT/CORBIS

A cinch for a flying robot

Drones take on power lines

AFTER the storm comes the drone. Electricity firm Commonwealth Edison, based in Illinois, has announced plans to start sending drones to inspect power lines.

The utility is the first in the US to receive permission from the Federal Aviation Authority to use drones for inspecting equipment. Since September, the FAA has selectively granted permission to a handful of companies interested in flying drones, like television and construction firms.

Commonwealth Edison has been considering drones since 2011, after a particularly bad spate of storms knocked out service for 900,000 customers. Before repair crews could be sent out, employees first had to drive or even walk the length of the power lines several times, noting the particulars of each problem: where it occurred, what type of wire was used, how many poles or transformers were affected. That meant a long wait for many before power was restored.

"Many of our lines are not along roadways and are not readily accessible," says chief operating officer Terry Donnelly.

Starting in a few months, the firm plans to fly drones fitted with cameras along lines in rural areas. They will record pictures and video of any damage. An infrared camera may also be added, to pinpoint hot spots on the line where failures are more likely.

"Drones with laser scanners could find the best path through a forest for a new power line"

The company will need to follow rules laid out for other drone operators, including keeping the craft away from airports and within the pilot's line of sight. It also says it will alert local officials ahead of time to expect the drones.

Brian Argrow, an aerospace engineer at the University of Colorado in Boulder, says utilities have been interested in drones for some time. "I think it's a long time coming. There's a risk reduction in using unmanned aerial systems to do the jobs rather than having humans and helicopters flying close to the power lines," he says.

Drones with laser scanners, built by Finnish start-up Sharper Shape offer yet more possibilities. Companies could use them to find the best path through a forest for a new power line. The software creates a detailed model of the ground below that even includes individual trees and an estimate of when they might topple.

And San Diego Gas and Electric (SDGE), a public utility in California, started experimenting with drones last year. Many of its power lines can only be accessed by helicopter, an expensive option. It hopes to use drones both for routine inspections and in the event of emergencies, like brush fires.

"We're always inspecting our system," says Hanan Eisenman, a spokesman for SDGE. "This tech would allow us to do it a lot quicker and a lot more efficiently." Aviva Rutkin ■

COVERED FROM THE AIR

Insurance adjusters want to get airborne. Last week, US insurance giant State Farm received permission from the FAA to start drone trials. USAA in San Antonio, California, has also filed requests.

The companies say drones will speed up claims processing by allowing them to quickly inspect damaged roofs after a major storm, for example.

Drones are "one more innovative tool to help State Farm customers recover from the unexpected as quickly and efficiently as possible", said Wensley Herbert, operations vice president of State Farm, in a statement.

ONE PER CENT

ROLF OLMOMENT/GETTY

Music tracker

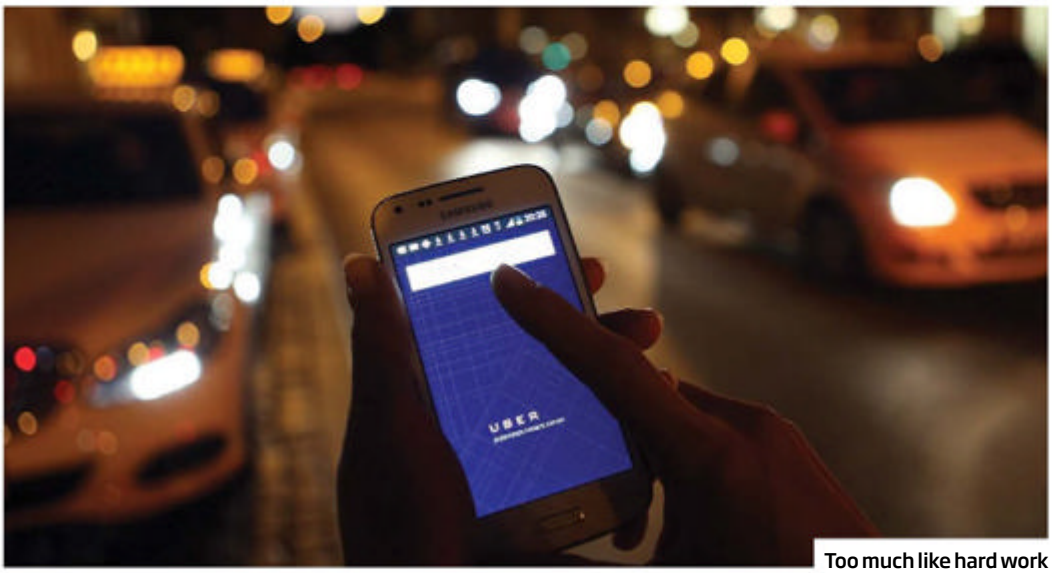
Got a licence to play that song, sir? Software called TraxAir, a Shazam-like music-recognition technology, listens out for licensed music so that artists can be paid. It can listen to TV, radio and web broadcasts, and even works in busy clubs. It can also recognise a track that has been heavily edited. The software is designed to help collecting societies – which dole out royalties to artists and record labels – to find out when a licensed track has been played.

"You basically have a tool to take your audience with you"

Meerkat founder **Ben Rubin** tells *USA Today* about his live-streaming app, which lets people watch what you are filming from your smartphone. Meerkat was a massive hit at the recent SXSW festival in Austin, Texas.

Electric moves

Forgot your charger? No worries. In future you'll be wearing one. A new fabric made by researchers at Sungkyunkwan University in South Korea can generate electricity just from the motion of the human body. A jacket made of the fabric was used to power LEDs, a liquid-crystal display and a remote keyless-entry system for a car.



ADAM BERRY/GETTY

Too much like hard work

Call me a cab!

Will automatic hailing of Uber taxis by lifestyle apps catch on?

THE coffee pot in your kitchen finishes brewing with a click. You fill your cup, pack your bag and run out the door. A car is waiting to whisk you to work. But you didn't call this car – the coffee pot did.

This is the promise of a small update that car-dispatch company Uber made to its software last week. The firm is letting third party developers have access to the software that triggers the request for a car, allowing them to summon cars automatically.

Until now, anyone who wanted a car could manually request one via the app, mobile website or text message. The idea has been a huge success, with the service now available in 56 countries – although it has made plenty of enemies along the way (see "Uber under fire", right). It has also recently announced plans to hire 1 million female drivers by 2020.

Uber's first ever hackathon will run from 17 March to 17 May to see what developers can do with the new capabilities. The first prize for the best new Uber app is $2000, a return flight to San Francisco and a two-night hotel stay in the city. More than 600 developers have registered to compete so far.

"The first Uber app was delightfully uncomplicated, with just one button to request a black car," Uber's Scott Woolsey Biggart wrote in a blog post announcing the new capability. "Developers now have the ability to programmatically request an Uber."

It is easy to imagine the future this kind of automation puts within reach: a driver waiting outside your office as you leave your final meeting, alerted by your online calendar; a car to meet you at the end of your train ride, summoned by interaction between Uber, mapping apps and public transport apps.

"A driver could wait outside your office as you leave your final meeting, alerted by your online calendar"

In a world where more and more everyday objects come with an internet connection, or can use the one in our phones, any object or machine can give the signal for an Uber car to head your way – such as your coffee pot. Or your alarm clock could be ready to call a cab 20 minutes after your final snooze. But is it going to make a big difference to our lives?

"Most people don't realise how important this is," says Thilo Koslowski, an analyst at technology research firm Gartner who focuses on automotive IT. "It's definitely a big deal. Getting a car becomes very seamless."

"I think you'll see deeper integration with other services, such as OpenTable for example," he says. At the minute, this restaurant booking app just pushes the restaurant address into Uber so that the user can call a car to pick them up from there. Uber's new tech lets OpenTable call cars all on its own. "Now OpenTable can determine that you're done eating and suggest that we call a car for you now," says Koslowski.

By opening up the ability to request cars to other software, Uber is also opening itself up to bugs in that software. With Uber's drivers as the only remaining human link in the chain, a plausible consequence of a bug might be to send multiple drivers to the same physical address. However, Uber already has systems in place to monitor their network for unusual behaviour and ought to be able to catch oddities like this.

Koslowski says that while the potential for automated Uber requests is huge, it will be important to introduce the technology slowly at first. "The options are limitless at this point. But consumers have to get used to this," he says.

The company's mission, first stated by CEO Travis Kalanick in a blog post late last year, is to provide "transportation as reliable as running water, everywhere, for everyone". By integrating itself with the rest of our digital lives, that vision might be getting a little closer.

Hal Hodson ■

UBER UNDER FIRE

Uber is used to falling out with people, usually local taxi drivers, but last week was particularly bad.

French police raided Uber's Paris offices on 16 March as part of an investigation into its carpool service, Uberpop. At the same time, a Frankfurt court banned Uberpop in Germany, ruling it illegal due to drivers' lack of a professional licence.

Earlier this month, Uber suspended its cheaper UberX service in South Korea, as part of a concession to the taxi industry. The service was even used to unwittingly supply a getaway car in New York.

But it's not all bad news for the firm: there are now 14,088 Uber cars compared with 13,587 yellow cabs in New York.

upp™

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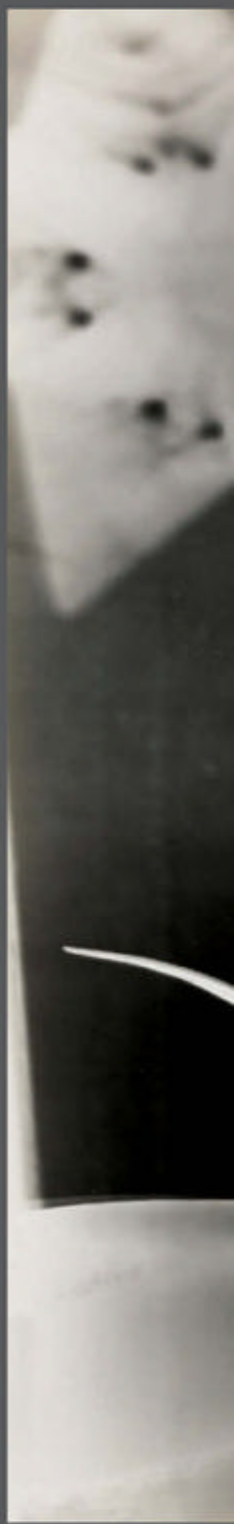


Leaf and Prism (1938)
Photograph, gelatin silver print on paper
348 x 277 mm

Lily and Egg (c.1939)
Photograph, gelatin silver print on paper
355 x 284 mm

Silhouettes in reverse

THEY may look like conventional photographs, but no cameras were used in the making of György Kepes's "photograms". Instead, the artist arranged objects directly on top of light-sensitive paper, then illuminated them. Kepes showed just as much enthusiasm for scientific and mechanical subjects as for natural forms, and this is reflected in the 80 photographs, photomontages and photograms now on display in Liverpool, UK, where leaves, eyes and feathers rub up against cones and prisms.

Hungarian-born Kepes was a member of Germany's Bauhaus art movement, which between 1919 and 1933 combined craft, technological innovation and fine art in pioneering ways, to international acclaim. The Nazis hated the Bauhaus, and Kepes, like many of his peers, ended up in the US.

Kepes arrived in Chicago in 1937, where he worked for his old friend, the artist and photographer László Moholy-Nagy, at a new art school dubbed "the New Bauhaus", later the Institute of Design. The images here date from the years Kepes spent as head of the school's hugely influential Color and Light department. His pupils included Saul Bass, who designed posters and title credits for Alfred Hitchcock and many others.

Kepes's work is on show at Tate Liverpool **until 31 May.** Simon Ings

Photographer

György Kepes (1906-2001)

When Earth bites back

Two centuries after the biggest volcanic eruption in recorded history the world is ill-prepared for an inevitable repeat, warns **Bill McGuire**

TWO hundred years ago, a simmering tropical volcano tore itself apart in spectacular fashion. Mount Tambora, on the Indonesian island of Sumbawa, erupted in a colossal blast that led to the deaths of more than 70,000 people in the region. So large was the eruption that its reach extended far beyond South-East Asia, loading the stratosphere with 200 million tonnes of sulphate particles that dimmed the sun and brought about a dramatic cooling with widespread ramifications half a world away.

The extended climate disruption saw 1816 dubbed the "year without a summer". There was a wholesale failure of harvests in eastern North America and across Europe, contributing to what economic historian John Post has called "the last great subsistence crisis in the western world". Famine, bread riots, insurrection and disease stalked many nations, while governments sought to cope with the consequences of a distant geophysical phenomenon they didn't understand.

Much of the world was taken by surprise and was utterly unprepared for the impact of the eruption. Would we be similarly caught out should another Tambora occur tomorrow?

We still so often seem shocked when geophysical threats become a reality. Floods, earthquakes, volcanic eruptions and the rest form a normal part of the way the world works, but time and again, societies are ill-prepared.

This troubling lack of readiness was best demonstrated by the

2010 eruption of Iceland's Eyjafjallajökull volcano, a geological event that probably affected more people than any other in modern times. The cancellation of 100,000 flights as ash soared far and wide played havoc with the travel plans of 10 million people and left airlines €1.3 billion out of pocket.

The consternation of governments and the aviation industry when faced with a moderate eruption of a European volcano says everything about our apparent inability to foresee events that aren't that unusual. After all, eruptions in Iceland aren't uncommon and we only have to go back to 1947 for the last time a large Icelandic ash cloud made an unwelcome appearance in European airspace. Not long at all really, but long enough for the threat to have been disregarded and left off the UK National Risk Register of Civil Emergencies.

The fact that Icelandic eruptions were added to the 2012 version of the register and flagged as one of the highest priority risks facing the country says a lot about the manner in which governments and their agencies tend to relate to potential geophysical threats without recent precedent. First ignore them; then inflate them.

"We still so often seem shocked when geophysical threats become a reality. Societies are ill-prepared"

Unlike the societies of the early 19th century, we are very much alive to the fact that major volcanic blasts can have a severe impact on climate. Yet we tend to understate volcanic threats beyond those in our own backyard. With eruptions capable of causing significant global cooling occurring perhaps as frequently as every few hundred years, this is something that could come back to bite us.

It would be wrong to give the impression that the post-hoc manner in which the UK Risk Register recognises geophysical threats is unique. This is an issue for many countries and reflects a general approach that is symptomatic of the way societies think about the potential harm from relatively infrequent, but high impact, natural events. Broadly speaking, people cross their fingers and hope they won't happen on their watch.

Nowhere has this been better demonstrated than in Indonesia, where the critical tsunami threat was vigorously flagged by US geologist Kerry Sieh and others prior to the disaster on 26 December 2004. With no Indian Ocean warning system, the tsunami that struck took the lives of citizens from 57 countries and transformed our view of geophysical hazards. For a time it focused attention on rare phenomena capable of having regional or global impacts.

One result of this was the establishment of a Natural Hazard Working Group in the

UK in 2005 by then prime minister Tony Blair, of which I was a member.

The key recommendation of our report to the government was to set up an International Science Panel for Natural Hazard Assessment, with the job of identifying, cataloguing and better characterising those geophysical risks with the potential to have a high impact, both on a regional and global scale.

This would address gaps in knowledge, facilitate discussion, debate and the pooling of information, and provide a known channel through which scientists could advise decision-makers on potential future threats. The proposal was drawn, with some enthusiasm, into the machinery of the United Nations, from which it has disappointingly, although perhaps not surprisingly, yet to emerge.

Initiatives such as the Global Earthquake Model, supported by the Organisation for Economic Co-operation and Development, and the University of Bristol-hosted Global Volcano Model go some way towards increasing our knowledge and understanding of some geological risks. But there remains an urgent need for a unique, overarching body to address all large-scale geophysical threats, that would also constitute an authoritative, go-to hub for decision-makers.

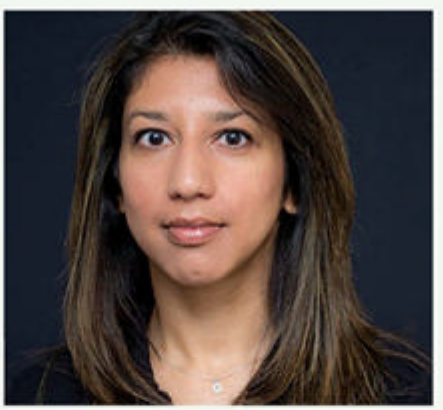
Forewarned is forearmed. If we want to be geared up and ready when the next Tambora blows, we need to put in place the sort of framework that will facilitate a step-change in the level of awareness and understanding of our planet's top-end geophysical threats. ■

Bill McGuire is professor emeritus in geophysical and climate hazards at University College London and author of *Waking the Giant: How a changing climate triggers earthquakes, tsunamis and volcanoes* (Oxford University Press, 2012).

ONE MINUTE INTERVIEW

Putting whiffs into words

English speakers often struggle to describe even basic smells, says **Asifa Majid**. Is that down to the language itself?



PROFILE

Asifa Majid is a professor at Radboud University in Nijmegen, the Netherlands, where she explores the nature of categories and concepts in language, including cross-cultural differences in odour perception

Why study the language of olfaction?

There are centuries-old ideas that humans have evolved to be visual or auditory creatures, and that our senses of smell, taste and touch just aren't as important any more. We're looking to see whether that's reflected in different languages as well.

Are there languages which excel at describing smells?

Speakers of the Aslian languages – found throughout the Malay Peninsula – are particularly good at expressing olfactory experiences. For the Jahai group, for example, who live a hunter-gatherer lifestyle, we found that smell was as easy to talk about as colour – unlike in English.

How many smell words do the Jahai use?

They have about 12 that describe specific smell characteristics. These are words that can only be used for smells. For example, a term pronounced "pl'eng" is used for fresh blood, raw meat, mud, stagnant water, fresh fish, otters, some species of toad… These are different kinds of objects, but there seems to be a smell quality common to them.

What's a good smell-specific word in English?

A term in English that really picks up on a specific kind of smell quality is "musty" – something like when you open a door that's been closed for a long time, or maybe the smell of old books.

How good are English speakers at articulating what they smell?

We gave Jahai speakers and English speakers the same smell and asked them to describe it. Jahai speakers were quick and consistent. With English speakers, nearly everybody gave a different and lengthy description for the same smell. For the smell of cinnamon, for example, one participant went on and on, like "I don't know how to say it" and "I can't get the word" and "like that chewing gum smell" and finally "Big Red gum". It was hard for most English speakers to identify even the common smell of cinnamon.

Why do English speakers struggle when the Jahai don't?

Perhaps it's because the Jahai live in a tropical rainforest, where smells are simply more salient. But there seems to be something culturally different, too: people in the West seem to do everything they can to get rid of smells, and in many contexts odour is a taboo topic. This might be linked to changes in our smell environment since the industrial revolution. If you read stories from the UK or France from before the revolution, there's sewage in the streets and people are using perfume to cover up body odour. These days, we do everything we can to sanitise our environment.

What lessons do you draw from your cross-cultural studies of smell?

Our work with the Jahai is exciting because it shows us that we have the potential to experience our environment in so many different ways. It makes you rethink your way of being in the world.

Interview by Elizabeth Landau

Sackcloth and ashes on Threadneedle Street

The financial crisis exposed some serious problems with economic orthodoxy. It's time to seek outside help, says Bank of England research chief **Andy Haldane**

The Bank of England is opening up its research efforts. Why?
Historically our research has been confined to this building and we haven't been very good at spelling out what we don't know. For the first time in our 320-year history, we are reaching out to researchers beyond the bank. We know that modern challenges can't all be resolved in-house, so we're hoping others will help us. It's a more crowdsourced, open-access approach.

Why did you decide a change was needed?
It is partly a sackcloth-and-ashes response to the global financial crisis, because some of our models and ways of thinking didn't bear the scrutiny that they came under. As a discipline, economics has been quite blinkered. In the light of the crisis, what better time to do some more cross-fertilisation between disciplines?

What are you hoping to achieve?
We're trying to make better sense of social systems like the economy and the financial system. We've already begun to make strides. I have tried to fuse bits of economics with physics, epidemiology, psychology, anthropology and one or two other ologies, to try to make sense of the world.

Where do you think progress will come from?
There's already been some. Behavioural economics has become sexy over the last ten years. In our old models, everyone was deemed to be a fairly efficient processor of information. But we know from psychology and sociology that that's not how people make decisions. We're all riddled with behavioural biases, and we make decisions in a world that's messy and noisy and uncertain, and emotion, fear and greed come into it – that's what humans are.

All this sounds completely obvious now, but those were not the edifices on which we built our models of the economy. They need to be.

What else did economists get wrong?
One of the guilty secrets of the pre-crisis period is that institutions, including banks, didn't form a big part of the models we were using to make sense of the economy. In some cases they played no part at all.

We had many fat years, remember, where growth had been good, inflation pretty low, and the financial system had behaved impeccably. So we weren't thinking about the banking system as an acute source of threat or instability. There were some – though not the Bank of England – who claimed that financial-system risk had been done away with.

"In a noisy, messy system, sometimes the best you can do is avoid the worst"

That was a pretty big mistake…
There's a book looking at the history of financial crises called *This Time is Different*, by Carmen Reinhart and Kenneth Rogoff. The title is meant to be ironic, because the prevailing mood of any given crisis is that it is different. But this crisis was different. We have not had a genuinely global financial crisis before – one that has taken in pretty much every country on the planet at pretty much the same time, at pretty much the same scale.

When Lehman Brothers went down in 2008, pretty much every country fell off the cliff because we are networked in a way that we never were before.

What new kinds of information do you need in a networked world?
One of the key elements of our new agenda is a better understanding of how social systems behave under stress. We've started investing in new data sets and databases – social media information and the like – to help us do that.

How can social media help us understand the economy?
In the run-up to the Scottish referendum, we were closely monitoring Scottish banks for any signs of flight of deposits. One way of doing that was to phone the banks every few hours. But we also set up a system that monitored social media. For example, we looked for tweets that contained the words "Scottish bank", "referendum" and "panic" or "run" and plotted the online traffic.

There wasn't any real sign of panic building up. We don't yet have an example of a bank-run type behaviour that's been picked up by social media – but the dynamics of financial crises are no different in many respects to behaviours during the Arab Spring or the 2011 London riots, which we know were picked up by social media, so this will be a source for us.

What other approaches are you using?
The standard way of measuring employment in the UK is to go around and count heads, asking people whether they have a job or not. The infrastructure needed to do this is costly. Alternatively, we can track the number of Google searches on the term "jobseeker's

Photographed for New Scientist by David Stock

PROFILE

Andy Haldane is chief economist of the UK's central bank, the Bank of England, and a member of its Monetary Policy Committee

allowance". If you do that, and plot that series against the official unemployment rate, you see a strikingly close match. One of the lessons we are learning is that what people are saying matters just as much as what they're doing.

We're not planning to cast aside all of our existing data. But should we make use of the data that is becoming available at a rapid rate of knots? Absolutely.

Is bitcoin on your radar?

Yes. A digital currency – be it bitcoin or something else – could make significant inroads into how we think about and use money. The clever bit about bitcoin is that it solves a problem that had previously been seen as largely intractable, which is how to achieve authentication of a transaction without requiring a trustworthy, neutral third party, such as the state. This could be transformational for money and for other things.

Could it make a difference to what money looks like, how it functions, how the bank issues it? Maybe. These are the sorts of questions our new research agenda is about.

How will you apply what you are learning to protect the UK economy?

In a system that's very noisy and messy, sometimes the best you can do is avoid the worst. In other words, build lots of safeguards into that system. Some of our policy interventions over the last few years have been in that spirit.

We might also intervene to reshape financial networks, and some of our interventions have been of that structural nature, requiring banks to ring-fence different parts of their activity, for example. That was inspired by epidemiology, and models of forest fires.

If stability is the goal, does that mean you'll judge yourself as having succeeded if nothing happens?

Social systems need to go through upswings and downswings – and occasionally need to fail. It's how they fail that matters, ideally in ways that don't tip the economy over a cliff. That's what we're in the business of avoiding. I'll judge myself as successful if I make myself redundant. I think we're a few years away from that, but it remains my aspiration. ■

Interview by **Sean O'Neill** and **Richard Webb**

KNOW IT ALL

It's never too late to learn something new, but what's the best way to go about it, wonders **Emma Young**

EVEN when school exams are just a distant memory, our thirst for knowledge goes on. Whether we are after a new skill or fluency in another language, want to play a musical instrument or explore a new passion, we are lifelong learners. Even if we simply need to bone up on trivia to win the pub quiz or impress someone we fancy, our need to know is never-ending. So you would think we'd have learning down to a fine art. In fact, some of the most common techniques are pretty useless (see "What doesn't work", page 32). But the good news is we can share some of the secrets of successful learning, and no matter what your age or ability, they can work for you.

PASCAL LAFAY

01

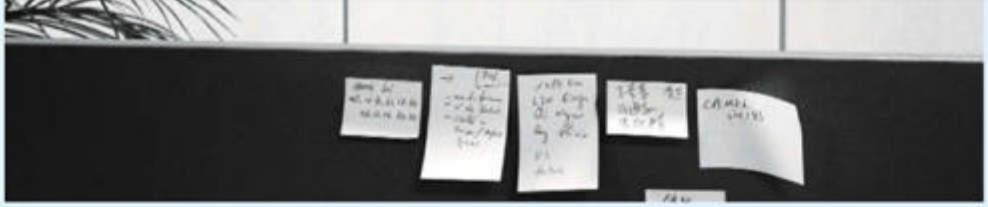
KNOW WHEN TO LEARN

Older adults have morning brains. A study on a group of people aged between 60 and 82 at the Rotman Research Institute at Baycrest Health Sciences in Toronto, Canada, found they were better able to focus and ignore distractions, and did better at memory tests, between 8.30 am and 10.30 am than between 1 pm and 5 pm. In fact, fMRI scans revealed that in the afternoon, these people's brains were "idling" – they had switched to the so-called default mode, associated with daydreaming. In younger adults, by contrast, areas related to the control of attention were still very active right into the afternoon.

However, to get the most from their efforts, younger people can time their learning, too. Another study found that 16 and 17-year-old girls performed better on tests of factual memory if they studied the material at 3 pm rather than at 9 pm, but acquired skills involving movements faster if they practised in the evening. "The results suggest it might be better to use the afternoon for studying languages, and the late evening for playing piano or another musical instrument," says Christoph Nissen at the University of Freiburg in Germany.

Why should timing matter? We know that sleeping after learning a new fact or skill helps consolidate memories. Nissen suspects that the "critical window" between learning and sleep is shorter for movement-related learning than for other types of memory. Whether adults can benefit as much as teenagers from these windows isn't clear. "There is evidence that adolescents have a higher capacity to learn – and they sleep better," he says.

›



02

QUIZ YOURSELF

In a landmark study on the importance of self-testing, Jeffrey Karpicke at Purdue University in West Lafayette, Indiana asked students to learn the meaning of 40 Swahili words (see "Swahili 101", right). Those who had to repeatedly recall these words during the training session scored an average of 80 per cent in a test a week later, while those who just studied the words without actively testing themselves scored an average of just 36 per cent. Other work since then backs up the idea that self-testing is more effective than some other common learning strategies, such as drawing bubble diagrams to represent ideas in a passage of text.

If that sounds like too much hard work, take heart. Nate Kornell at Williams College in Williamstown, Massachusetts, and his colleagues have found that what matters is trying to retrieve the information you are learning, rather than succeeding. Being given the correct answer seems, counter-intuitively, to be as big a boost to later performance as remembering it by yourself.

"This finding was quite surprising," says Kornell. "Memory researchers have long assumed that there are 'paths' in memory from the question to the answer and – here's the part that appears to be wrong – that you learn more by travelling your own path than by travelling part way, or the wrong way, and then being told the answer." His finding suggests we may have to rethink how memory works. But it also offers hope to lackadaisical learners everywhere.

03

LEARN WITHOUT LEARNING

It sounds too good to be true, but learning needn't be hard work. You can even do it when your mind is on something else.

Beverly Wright at Northwestern University in Evanston, Illinois, asked one group of volunteers to practise distinguishing between sounds of a very similar frequency. Another group spent half the time in active practice, and the other half just hearing the sounds in the background while they performed a written task. Both groups scored about the same on a final test – but only if the passive learning happened within 15 minutes of the active session; the effect vanished entirely if the delay was longer than 4 hours.

What might be happening? Wright thinks active training puts the neural circuitry involved in a particular task into a state conducive to learning, and that this state continues for some time after the training ends. While it lasts, similar stimulations to those that were being learned will be processed by the brain "as though they are occurring during active training", she says.

So far, Wright and her team have investigated only the learning of a skill rather than facts or events. But Lynn Hasher at the University of Toronto, Canada, and colleagues have found that a spell of passive learning following active study can also help older adults learn a list of words. The volunteers in her study reported that during the passive phase, they didn't even notice that the words were being repeated.

If you want to give it a try, take note: passive learning is more effective while you are doing something relatively undemanding. So you might want to listen to foreign vocab as you get the dinner ready, rather than while writing emails.

04

USE DISTRACTIONS

Find your attention wandering? Use this to your advantage. "People have an underlying assumption that divided attention is bad," says Joo-Hyun Song at Brown University in Providence, Rhode Island. It's true that if you frequently break off from studying to send a text message or to focus on a tune on your headphones, odds are you won't learn as well as you would in uninterrupted silence. "But learning has a later, skill-retrieval part," she adds. "People hadn't studied the role of divided attention in memory recall later." Doing just that, Song found that distraction while learning can be beneficial – if you are also going to be distracted when you have to use what you have learned.

It is common knowledge that context can boost learning. If you study a list of words while smelling vanilla, for example, you will probably remember more of them if the scent of vanilla is in the air during recall. Song found that divided attention can itself act as a powerful context. In her studies, people who were distracted during learning and recall performed just as well as those who weren't distracted on either occasion, and better than people who were distracted in only one situation. It didn't matter whether or not the distractions were the same on both occasions, but the degree of distraction had to be similar. Intriguingly, Song also found that divided attention was a more powerful learning aid than environmental contexts such as a smell.

There are important implications, she says. "In training, people should consider where they will actually acquire and use their skills." If you are going to have to remember what you have learned in an environment where you are likely to feel distracted – in a packed foreign city or a noisy pub on quiz night – you would actually do better to have distractions while you are learning.

WHAT DOESN'T WORK These common methods to boost learning are surprisingly useless

OLIVIER CULMANN/TENDANCE FLOUE

05

BUDDY UP

While solo studying is important, thrashing out difficult material with other people can pay dividends. Saundra McGuire, assistant vice-chancellor for learning and teaching at Louisiana State University, and chemistry Nobel prizewinner Roald Hoffman recommend you alternate group work with study time by yourself. Specifically, once you have tried to go it alone, you can benefit from the collective wisdom of a small study group of three to six people.

McGuire and Hoffman say that study groups need two key elements to promote "meaningful learning": discussion and problem-solving activities. If group members make up quizzes for each other, this can help them prepare for tests. However, after discussing the material, clarifying anything you are confused about, and using the opportunity to mock-test each other, you should then go back and work on the problems and get ready for any exams on your own, they say. ›

SWAHILI 101

Quizzing yourself while learning these Swahili words will dramatically improve your recall of them

adhama	**honour**
adui	enemy
buu	**maggot**
chakula	food
dafina	**treasure**
elimu	science
fagio	**broom**
farasi	horse
fununu	**rumour**
goti	knee
kaputula	**shorts**
ndoo	bucket
pombe	**beer**
sumu	poison
tabibu	**doctor**
theluji	snow
tumbili	**monkey**
usingizi	sleep
yai	**egg**
ziwa	lake

⊗ HIGHLIGHTING AND UNDERLINING ⊗ RE-READING IMPORTANT TEXTS ›

06

PLAY VIDEO GAMES

This may come as a pleasant surprise to the parents of teenage gamers. Gaming is the ideal downtime activity if you are learning to type or play a new sport or instrument – anything, in fact, that involves a fairly constant and predictable structure and requires the coordination of sensory input and physical movements. Just make sure it's action video games you play.

A team led by Jay Pratt at the University of Toronto, Canada, found that people who played action video games, such as *Call of Duty*, for at least 6 to 8 hours a week were faster at learning a lab-based task that involved hand-eye coordination. They weren't any better at the start, they just improved more quickly. Pratt thinks this is because gaming speeds up a person's ability to form accurate brain "templates" for hand-eye-coordinated action. "Action games, which have harder levels as the game progresses, place a lot of demands on the visual, cognitive and sensorimotor systems to constantly improve the efficiency of all these systems," he says. This is why they are more likely to have an effect on other sensorimotor tasks than something like *The Sims*.

It's hard to be sure what difference regular gaming would have on performance in the real world, since there are so many variables, Pratt concedes. "But if one is in a new job that requires a high level of sensorimotor skill, say, then playing several hours of action video games each week could be a worthwhile investment."

07

CHILL OUT

If sleep consolidates memories, would taking a break from studying have a similar effect? To find out, Lila Davachi at New York University scanned people's brains while they looked at a series of images, then asked them to think about whatever they wanted. During this rest period, there was increased activity in the hippocampus (involved in memory) and "thinking" regions in the cortex. What's more, the greater the activity in both regions, the better an individual remembered the images they had seen when tested later. Davachi thinks her work shows the consolidation of memories during rest.

If you have just studied a list of vocabulary or perhaps tried to memorise some key historical dates, then taking a proper break afterwards should help you to remember this information, she says. "This is something we don't appreciate much, especially when today's information technologies keep us working round the clock."

But what counts as a "proper break"? Davachi has been working on this too. What she has found, but not yet published, is that a rest can help consolidate memories as long as it activates different populations of neurons in the brain, or whole brain regions, from those that were active during the learning period. So if you have just put in some hard mental study, going off to practise your tennis backhand should do the trick. Having said that, a little lie-down might seem more tempting and may be even more productive. We still don't know the relative benefits of chilling versus taking a nap, when it comes to learning.

08

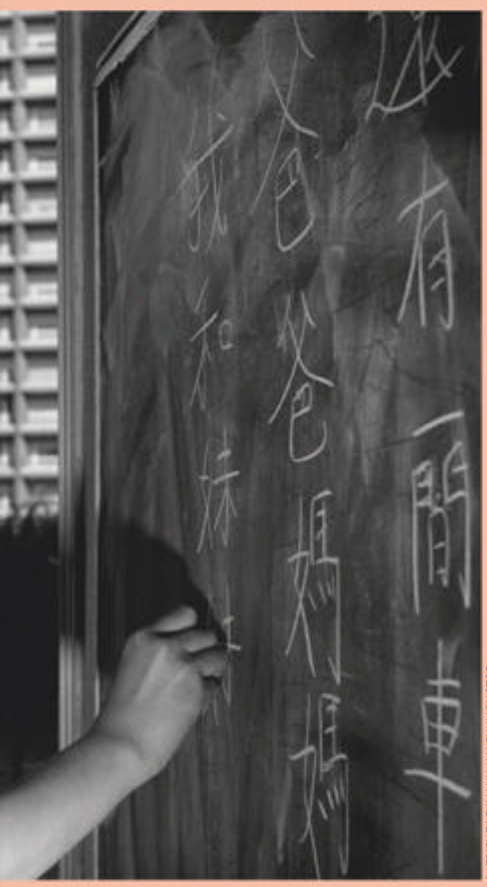
PRETEND TO TEACH

You are likely to remember something better if you think you might have to teach it later. Kornell discovered this when he gave students at Williams College 10 minutes to study a 1500-word passage about *The Charge of the Light Brigade*. Those who were told beforehand that they would have to pass on what they had learned to someone else later remembered more points from the text, and their memories were better organised, than those who thought they were simply going to be tested on the text.

Better yet, independent learners can trick themselves into reaping the benefits of this insight. "Our research shows that pretending

› ⊗ KEYWORD MNEMONICS ⊗ COPYING YOUR NOTES ⊗ ELABORATE MENTAL

that you'll have to teach will help you learn in the same way," says Kornell. And if you actually then do the teaching, all the better. There are many well-known cognitive benefits to asking yourself whether you can recast what you are learning in your own words, he adds. "It leads to active retrieval from memory, and helps with organising one's thoughts as well as identifying knowledge gaps that one needs to fill." Kornell and his team note that teachers often instruct their students to prepare for a test, but this doesn't encourage them to pick the learning strategy that should ultimately lead to a better score.



PATRICK ZACHMANN / MAGNUM PHOTOS

09

DO INTERVAL TRAINING

You've just learned a series of brilliant chess openings, so when should you go back and revise them to maximise your chances of actually remembering them when it counts? "The longer you wait the better," says Kornell. "There are limits on how long you should wait, but they are very, very long." It's true that waiting makes it harder to remember the information when you come back and test yourself, so it makes your life difficult and can feel like a bad thing. "But the harder it is, the more you learn. So when you need the information later, for example, when actually piloting that airplane or playing that chess match, you'll do better," Kornell says.

Refining this idea, Hal Pashler at the University of California, San Diego, and his team recommend spacing the intervals between revisions as a proportion of the time between initial learning and when you want to remember the information. They have discovered that the best interval to use depends on how long you want to remember something for. To maximise recall a week later, you should revise the info about two to three days after learning. "If you want to remember for a long time, it's good to have quite a lot of spacing, maybe at 10 per cent of the time," says Pashler. So if you need to recall something in a year, revise it about a month after learning and then monthly thereafter. To remember something for 10 years, you should ideally review it once a year. No one knows what brain mechanisms underpin this. But having long gaps between learning, revision and retrieval might tell your brain that this is knowledge you will probably need in the long term, he says.

Pashler's team is now trying to develop practical learning tools, based on their research. They have developed an algorithm that can generate personalised study spacing plans. The formula uses measures of how difficult the material is and how well a particular student is performing based on early test results. In one study of people learning Spanish, the team found that individualised plans improved retention at the end of the semester by 16.5 per cent, compared with 10 per cent for a one-size-fits-all spacing plan.

10

JUST DO IT

All is not lost – if you do find it hard to sit down and study, and you do badly in an exam or a performance as a result, don't beat yourself up about it.

Michael Wohl at Carleton University in Ottawa, Canada, and colleagues found that students who had forgiven themselves for procrastinating before an initial set of exams performed better in the next set and procrastinated less than students who hadn't. They also said they felt more positive.

Wohl thinks self-forgiveness allows us to shrug off negative feelings about ourselves, so helping to improve our performance in future. However, he stresses that this doesn't work for serial procrastinators. "We've found that self-forgiveness for chronic, unhealthy behaviour can help maintain the status quo – that is, continued unhealthy or poor behaviour."

If this sounds like you, you may need to take more drastic action. Learning requires willpower – self-control in the moment. Willpower is like a muscle, argues Roy Baumeister at Florida State University, so the more you use it, the stronger it gets. What's more, he has found that by exercising willpower in one area, you can boost it in another. By making an effort to do anything from keeping your house tidier to sitting up straight instead of slouching, you should also enhance your ability to just sit down and study or practise. What are you waiting for? Why not start right now? ■

Emma Young is based in Sheffield, UK. Links to studies appear in the online version of this article at bit.ly/learnonweb

IMAGERY ⊗ PERSONALISED LEARNING STYLES ⊗ SUMMARISING THE MATERIAL

BATTLE SCARS

War isn't just for the history books. It is for the geology ones too, say **Jan Zalasiewicz** and **Mat Zalasiewicz**

VERDUN, The Somme, Passchendaele, Gallipoli – the battles of the first world war have become bywords for death, destruction and human misery. Historically, they are just the tip of the iceberg. There have been countless thousands of battles, and still they go on: around 50 armed conflicts are raging right now. War shapes the past, destroys our present and will determine our future.

But could the scars run deeper? Does conflict leave a permanent mark within Earth itself? It turns out war isn't just for the history books – it can shape the geological strata in which Earth's narrative is written.

The earliest evidence of armed conflict dates back to around 13,000 BC and a mass grave in northern Sudan. Here 59 human skeletons were discovered, many bearing signs of violent death such as spear and arrowheads embedded in their bones.

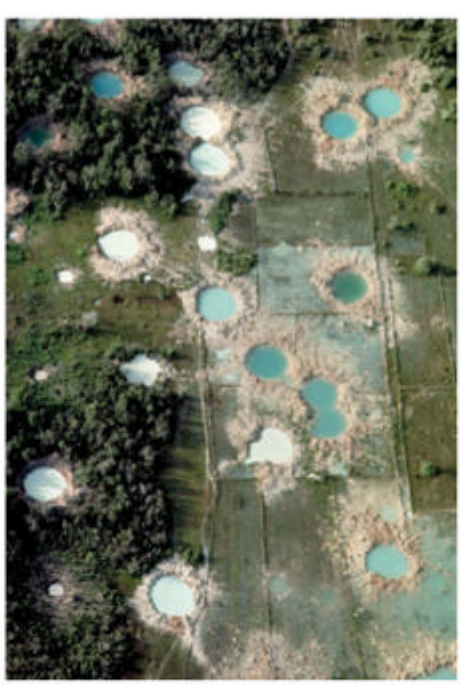
The wars of the ancients give some guide to how long the marks of war might last. The old battlegrounds were picked over, as the dust and smoke settled, by vultures, rats and human scavengers. Much later, teams of archaeologists moved in, finding smashed human skeletons and the remains of weapons such as flint arrowheads. Could these objects last longer and become geology rather than archaeology?

A few might. The simple materials of the old warriors have good geological analogues. Indeed, some are the essence of geology. There is little that is more hard-wearing than flint: tough and chemically resistant, it is one of the ultimate survivor rocks. A wooden lance can carbonise over time to become a lance-shaped lump of coal. But not everything will last that long: iron weapons, for example, may not fossilise so easily, as iron rusts at the surface and corrodes once buried.

What about the geological legacy of modern warfare? Here we enter uncharted territory. Some of these future fossils will be strange. Some will probably be huge. And some already encircle Earth.

Perhaps the most noticeable legacy comes from the scale and power of warfare. Gunpowder has been around for over a thousand years, and was mainly used to propel shot at people, ships and fortress walls. Then came Alfred Nobel and his discovery of high explosives that could be delivered using artillery. These were able to refashion entire landscapes, as the first world war showed so graphically: the battlefields of the Western Front were turned into muddy quagmires by incessant shelling. Entire hills could lose several metres in height in an intense bombardment.

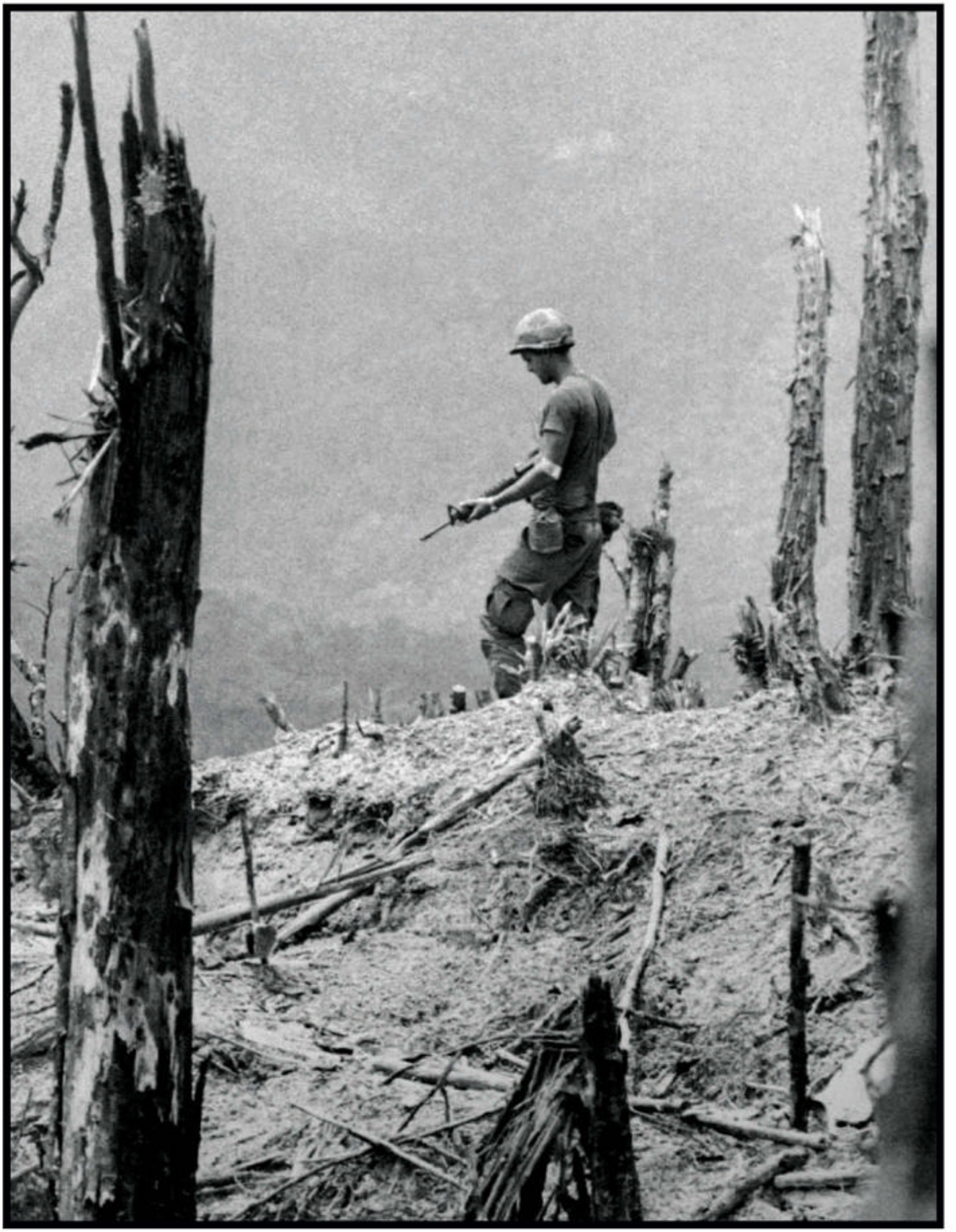
US B-52 bombers pummelled this area in Vietnam



This transformation was more than skin-deep. In 2006, soil scientists Joseph Hupy of Colgate University in Hamilton, New York, and Randall Schaetzl of Michigan State University in East Lansing compared the effects of shelling to bioturbation – the burrowing activities of worms and other invertebrates – which is widely preserved in the fossil record. They called the explosive production of a distinctive mass of metres-deep craters and churned earth and rock "bombturbation". This may also be compared to dinoturbation, the footprints and other disturbances left by giant dinosaurs and preserved for millions of years.

By the time of the Vietnam war, landscape transformation was no longer collateral damage but a primary war tactic to remove cover from the enemy – like the scorched earth practices of old, but carried out with massively greater firepower. Between 1965 and 1971, an area not much bigger than Texas was bombarded with twice as much high explosive as US forces used during the entire second world war. The region was pulverised by some 26 million explosions, with the green Mekong delta turned to "grey porridge", as one soldier put it. In Iraq, Afghanistan, Syria and elsewhere, bombturbation continues.

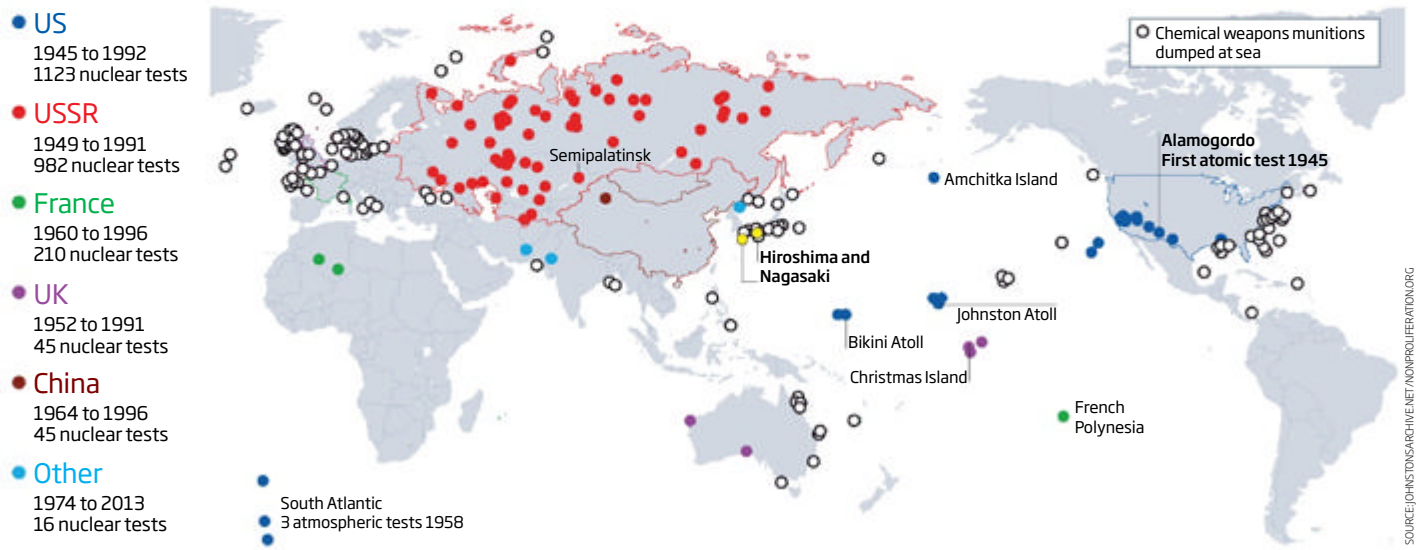
Bombturbation can continue even after the guns fall silent. Of the estimated 1.5 billion shells fired in the first world war, perhaps a quarter didn't explode on impact. Thousands are found every year, and people are still killed by them. Most of this unexploded ordnance lies buried, some 20 metres down. If it stays ›



MAIN: DAVID KENNERLY/BETTMANN/CORBIS. LEFT: TIM PAGE/CORBIS

Nuclear explosions and chemical dumps

The Earth is pockmarked by nuclear test sites and marine weapons dumps that could leave a lasting geological signature



buried, could it fossilise? This seems likely. Even if the steel eventually dissolves, and the explosive transforms to petroleum, a compressed carbon-impregnated impression will remain, like a crushed and flattened dinosaur skull in a sandstone slab.

Bombturbated mud also contains the bones of fallen soldiers. Of the million killed in the 10-month-long Battle of Verdun, only some 290,000 were ever found. The rest must lie somewhere within that bomb-churned stratum. These layers are akin to bone beds – concentrations of vertebrate fossils found in prehistoric rock. But there is one striking difference: in these human bone beds, the remains are virtually all of young men.

After battles, shattered cities need to be rebuilt. But what to do with the rubble? In some places, there was too much to simply build over. The tallest hill in the German capital, Berlin, stands 80 metres high and a kilometre in length. Called Teufelsberg (Devil's Mountain), it is now tree-covered and looks natural. But underneath is some 75 million cubic metres of rubble from Nazi Berlin, including the remains of Albert Speer's unfinished military college. The top of the Teufelsberg was annexed, ironically, for another conflict – it bears the domes of a US-run cold war spy station.

Will these war-derived land formations become the rock layers and fossils of future geology? Surely, over centuries and millennia, erosion will wear away even the deepest bomb crater and highest mountain of rubble? That's true for tectonically rising ground. But on coastal plains and subsiding deltas, the crust is going down, not up. Here, war-torn landscapes will be buried, first under water and then under new sediment layers, and begin to be preserved as rock strata. These are the kinds of environments that in the geological past entombed ancient landforms, like the debris spread inland by a tsunami. In them, today's giant bomb craters could easily become fossilised. The likely near-future sea level rise, as global warming bites, will only speed this burial, as land is submerged and taken out of the realm of erosion.

Buried at sea

Deep beneath the sea, fossilisation takes place even more readily. Some of the shipwrecks strewn across the sea floor are the result of naval battles, and these may be entombed and become "technofossils". But it is another relic of modern war that will likely leave the most striking message to the future. After both world wars, the exhausted armies were left with millions of unused bombs, including chemical weapons. There was neither the time nor the resources to make them safe; most were simply shipped out to sea and thrown overboard (see map, above).

PAOLO PELLEGRIN / MAGNUM PHOTOS FOR THE NOBEL PEACE CENTER

There are over a hundred known weapons dumps in the seas around north-west Europe alone. One of them, a submarine hollow called Beaufort's Dyke in the Irish Sea between Scotland and Northern Ireland, contains over a million tonnes of surplus munitions. Even larger dumping grounds were improvised elsewhere in the world.

How might an undersea bomb leave a lasting mark? Initially, sinking munitions will create impact deformations on the sea floor; rocks dropped from melting icebergs leave similar structures in strata. Later, corroding bombs can explode, especially if they are disturbed by a fishing vessel's trawling gear, for example. Explosions can continue for centuries afterwards, creating bombturbated layers on the sea floor. Or the explosives and chemical agents can seep out and kill off marine life. Dissolved TNT is highly toxic, to say nothing of mustard and nerve gas. Biological dead zones would be preserved as fossil-free layers of rock.

Bullets, too, may leave their mark. Around a trillion have been fired since the beginning of the second world war – that's a couple of thousand for every square kilometre of Earth's surface, both land and sea. How will they end up? Bullets are largely made of lead, which is chemically unstable in surface conditions and rare in nature. In soil, bullets slowly oxidise and corrode, leaving bullet-shaped holes filled with lead minerals, such as the clear crystalline cerussite or the yellow anglesite. Bullets falling into oxygen-starved sea floor

muds might turn into silvery galena, or even remain as the metal itself. The killing fields will transform into a mineralogical garden.

War has spurred other kinds of geological novelty, including the transmutation of elements. The development and testing of nuclear weapons spread human-made elements such as plutonium and technetium around the world, leaving a radioactive fingerprint on soils and sediments. For good measure, it also released an extra dose of carbon-14 to be incorporated in the tissues and bones of living organisms.

Little of this pollution relates to war itself – the atomic bombs that destroyed the Japanese cities of Hiroshima and Nagasaki left negligible radioactivity. The worldwide radioactive "bomb spike" in sediment layers is a legacy of the sabre-rattling of the cold war in the 1950s and 1960s, when over 500 nuclear weapons were detonated at Earth's surface and in the atmosphere. The bomb spike can even be found in Antarctic snow layers. Small wonder that it is being suggested as a primary characteristic for the mooted Anthropocene Epoch, when humans became the primary driver of Earth's geological processes.

In the 1960s, concerns about these rising radioactivity levels forced nuclear tests underground. Around 1350 were carried out at test sites such as Yucca Flats in Nevada and Semipalatinsk in Kazakhstan, leaving a distinctive signature in the rocks. The force of each explosion first created a spherical cavern lined with molten, radioactive rock. The cavern walls and roof usually then collapsed to form an underground mass of radioactive rubble and melt hundreds of metres across, with fracture networks extending outwards. This caused the land surface to subside and form a steep-sided crater, its edge defined by circular fault lines generated by the explosion. Extending up to 2.5 kilometres below ground, these unique geological structures will persist for many millions of years.

The cold war nuclear stand-off may yet have a sting in its tail. The Kara Sea, north of Siberia, is a huge dumping ground for nuclear waste. Fourteen rusting nuclear reactors lie there, cut out of obsolete submarines and power stations. An entire Soviet nuclear submarine, K-27, scuttled in 1982, lies nearby in Stepovogo Bay, its reactors still charged with nuclear fuel.

Underwater Chernobyl

More reactors and submarines lie in the Barents Sea to the west, and off the coast of the Kola Peninsula. They won't explode, but they could go critical and make a kind of underwater Chernobyl. If a massive submarine radiation leak occurred, it would cause environmental havoc, leaving a radioactive layer on the sea floor as a geological legacy.

COURTESY EVERETT COLLECTION/REX

First world war ordnance (left); Nevada's nuclear landscape at Yucca Flats (right)

There are other war-related fossils: hardened concrete bunkers and underground silos, military roads and runways, and the toxic, oil-soaked ground left behind when armies move on. These rock-borne signals won't be small, for war is big business. World military spending is about $1.7 trillion a year – about 2.5 per cent of global GDP – and the associated energy use is enormous. The US Department of Defense accounts for over 80 per cent of the US government's total energy consumption.

> "Craters from underground nuclear tests will persist for millions of years"

What about the effect on wildlife, the future palaeontology of Earth? This is more complex. In some areas wildlife is devastated, for instance by the carpet bombing and Agent Orange defoliant that destroyed Vietnam's forests. But peacetime activities of agriculture and urbanisation can devastate biodiversity, too. In fact, wildlife often copes better with sporadic bombs and bullets than it does with chainsaws and tractors. Many military training areas are home to rare species; it has even been suggested that such areas be given official status as nature reserves. War-torn areas, too dangerous for humans, may be havens for some creatures. The landmine-ridden Iran-Iraq border region is a place where the endangered Persian leopard can walk today in relative safely.

Can one avoid the geological impact of war by not fighting with anyone? Seemingly not. Switzerland is a determinedly neutral country, yet many of its mountains are engineered in readiness for war, the bedrock riddled with networks of roads, tunnels and chambers big enough to hide planes and even armies. If anyone tries to invade, weaponised mountainsides will trigger landslides to sweep through valleys.

Perhaps the greatest impact of war on Earth will be indirect, resulting from that characteristic of humanity that has underlain conflict ever since our species arose: tribalism. We segregate into groups and nation-states, compete for resources and guard the interests of our own group jealously. That makes it difficult for us to act together when a common problem arises. In far future times, it might be asked how an intelligent, technologically advanced species clearly saw the signs of imminent climate change and then reacted too little, too late. Inaction on this scale could change the world's geology as nothing else has in our planet's history.

Maybe we won't get that far. Our belligerence could lead to all-out nuclear war. What then, geologically? A thin, soot-stained nuclear winter layer will probably form, rather like the Cretaceous-Tertiary boundary that marks the death of the dinosaurs, though sprinkled with plutonium rather than asteroid-derived iridium. The plutonium will decay away in a fraction of a million years. How future geologists would interpret this layer is hard to know. But they may also notice that the layer also marks the upper limit of a certain type of geological deposit – one of bombs, bullets and human bones. ■

Jan Zalasiewicz is a geologist at the University of Leicester, UK. Mat Zalasiewicz is a freelance editor based near Nottingham, UK

What science can do

Circulating tumour DNA
AstraZeneca has pioneered the use of circulating tumour DNA (ctDNA) in the diagnosis of cancer. Pieces of DNA break off from a tumour and circulate in the bloodstream where they can be analysed to give genetic information about a patient's tumour. This allows healthcare professionals to determine the right treatment for the patient using a non-invasive blood test.

Laying the foundations for open innovation

In February this year, Cambridge City Council granted planning permission for the newest addition to the Cambridge Biomedical Campus: AstraZeneca.

With excavation set to begin later this spring for our stunning, new, state-of-the-art Global R&D Centre and Corporate Headquarters in Cambridge, this truly is a significant milestone for our company. It's also a momentous event for the Campus which, dating back to the '60s, has played a major role in establishing Cambridge as a global centre of biopharmaceutical excellence. Having attracted world-leading academic scientists and clinicians, as well as producing new biotech start-ups, today the Campus is a thriving hub of innovation and collaboration. At AstraZeneca, we're excited about contributing to this culture of success and helping the Campus realise its vision of becoming one of the leading biomedical centres in the world by 2020.

Open innovation for a greater impact

Ground-breaking science and collaborative innovation lies at the heart of our work and these new premises will foster an open, supportive environment of active, collaborative learning. Whether working in the labs or in Biometrics, in Projects or Regulatory, there are opportunities for everyone to learn about, and contribute to, the success of our research, drug development and commercial growth.

While we already collaborate with a myriad of external organisations, we're excited to make even more of these connections in Cambridge. It's our belief that by openly collaborating, we can accelerate the development of new medicines, and make a greater difference for patients, their families, our stakeholders, and society in general.

A cutting-edge portfolio

We constantly work at the forefront of biopharmaceutical research. To ensure we do this as successfully and efficiently as possible, we've focused our research on three therapeutic areas: cardiovascular and metabolic diseases, oncology, and respiratory, inflammation and autoimmunity.

Take our work in oncology for example. For over 40 years, we have developed cancer drugs which have contributed to significantly increased survival rates for cancer patients around the world.

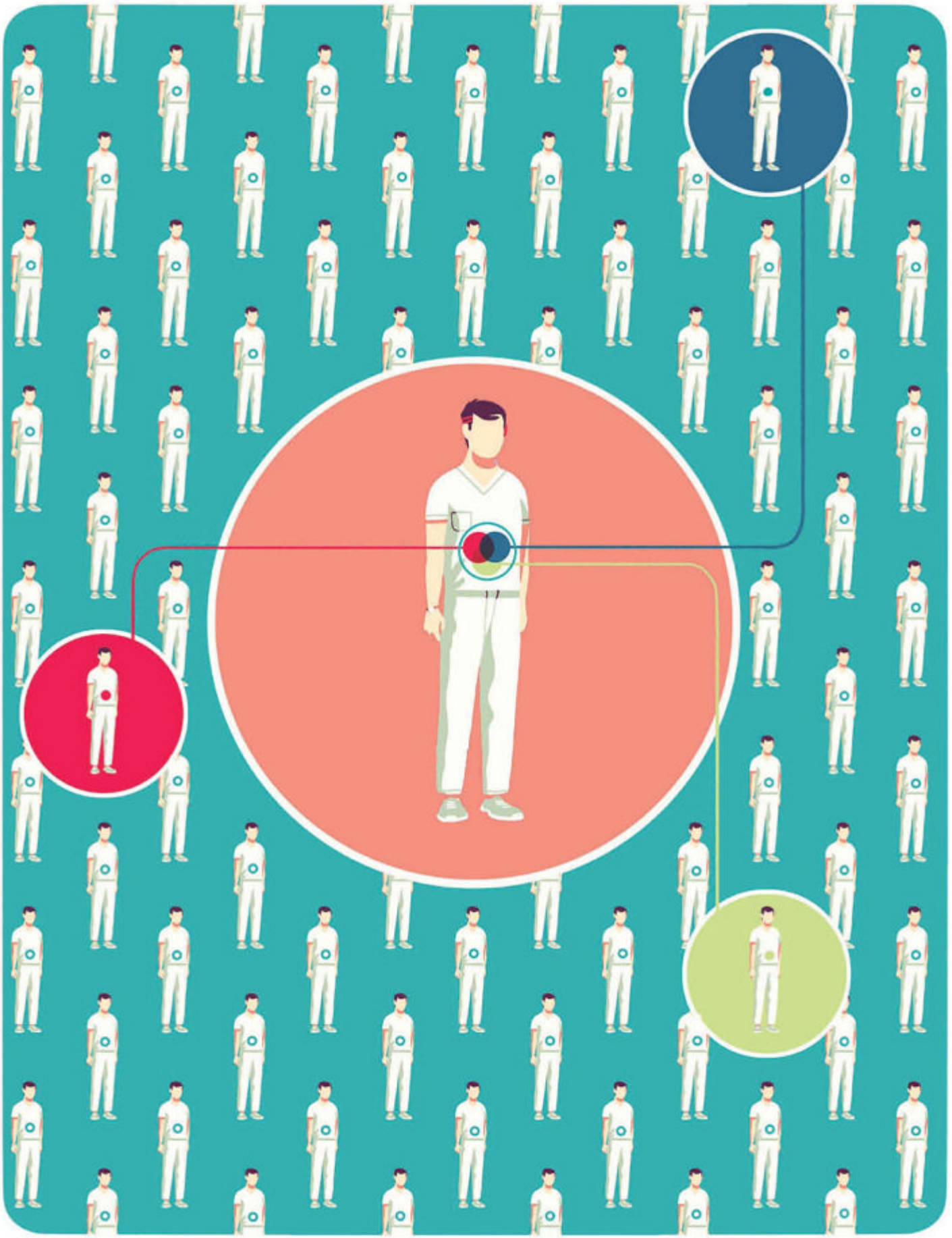
We're also one of only a handful of companies conducting small molecule, large molecule and immuno-oncology research, and soon we'll be doing it all under one roof. In 2014, our oncology pipeline has shown huge progress. Six of our assets are progressing into late stage clinical trials and 24 new molecular entities are currently in development between Phase I and Phase III. All this demonstrates that we're committed to pushing the boundaries of science to become leaders in the field of oncology.

What science can do

It's an exciting time to be a part of AstraZeneca, and our move to the Cambridge Biomedical Campus speaks volumes of the City's global importance as a location for biopharmaceutical research and development. We're focused on advancing the discovery and development of ground-breaking medicines and look forward to fostering collaborations that will help us drive medical progress, even further. With the chance to work closely with world-renowned academic research institutions, pre-eminent hospitals and cutting-edge biotech companies, we can't wait to see what science can do.

To find out more about AstraZeneca's boundary-breaking science in Cambridge, visit

www.cambridge-jobs.astrazeneca.com



Grow your enemy

If you had cancer, would you want to make clones of your tumour? It might help you get the best treatment, says Linda Geddes

"The first doctor I saw told me I had six months to live," says Antonia Crawford. She was diagnosed with advanced pancreatic cancer in August 2013, at the age of 43.

She went on to have the standard treatments but, aware that they might not be the most effective against her particular cancer, Crawford also did something quite extraordinary: she had bits of her tumour implanted into a group of mice. Once the tumours had grown in them, the mice were given a range of different treatments, in an effort to find the drug combination that would work best for her. "As a patient, I just didn't have the time, nor could my body have gone through trying all these different drugs on myself," Crawford says.

It's too early to say whether this particular method improves individuals' chances of survival. But there is a lot of interest in the idea. Many groups are working on the somewhat grotesque challenge of growing three-dimensional copies of people's tumours outside the body – essentially, cloning cancers. Simply put, the idea is that if you want to know your enemy, you need to grow your enemy.

While cancer cells have long been grown outside the body, it isn't as easy as you might think. Some, such as the famous HeLa strain of cells long used in research, thrive outside the body, but most cancer cells die if they are stuck in a dish. And even when they do survive, there is a big difference between a bunch of cancer cells growing in some fluid in a dish and a tumour growing in someone's body.

Solid tumours are a bit like organs: they have a mix of cell types growing in a three-dimensional structure and fed by a dedicated blood supply. "How cells behave in 2D in a plastic tissue culture flask is just not that relevant to what happens in the body," says Frances Balkwill of Barts Cancer Institute in London.

Balkwill's team and others around the world are trying to grow realistic tumours outside the body using tissue engineering, but this approach is still at an early stage. The tried and tested way of growing tumours in 3D is to implant bits in mice with an immune system altered so as not to attack human cells. Such xenografts have been used for drug testing since the 1980s.

Now Champions Oncology – the company that Crawford turned to – is selling this service directly to individuals with cancer. "Cancer is a unique disease, and it is very difficult to work out why some drugs will work for one patient but won't work for another; we need a more rational way to figure out what patients should and shouldn't try," says Ronnie Morris, the company's president.

This everyone agrees on. Cancers are already classified into hundreds of different types depending on which tissue they originate in and what they look like under a microscope. But really there are many millions of kinds. Cancers typically have hundreds of mutations, along with even more epigenetic changes. Every tumour is unique – and constantly changing and evolving.

> "She had bits of her tumour implanted into a group of mice"

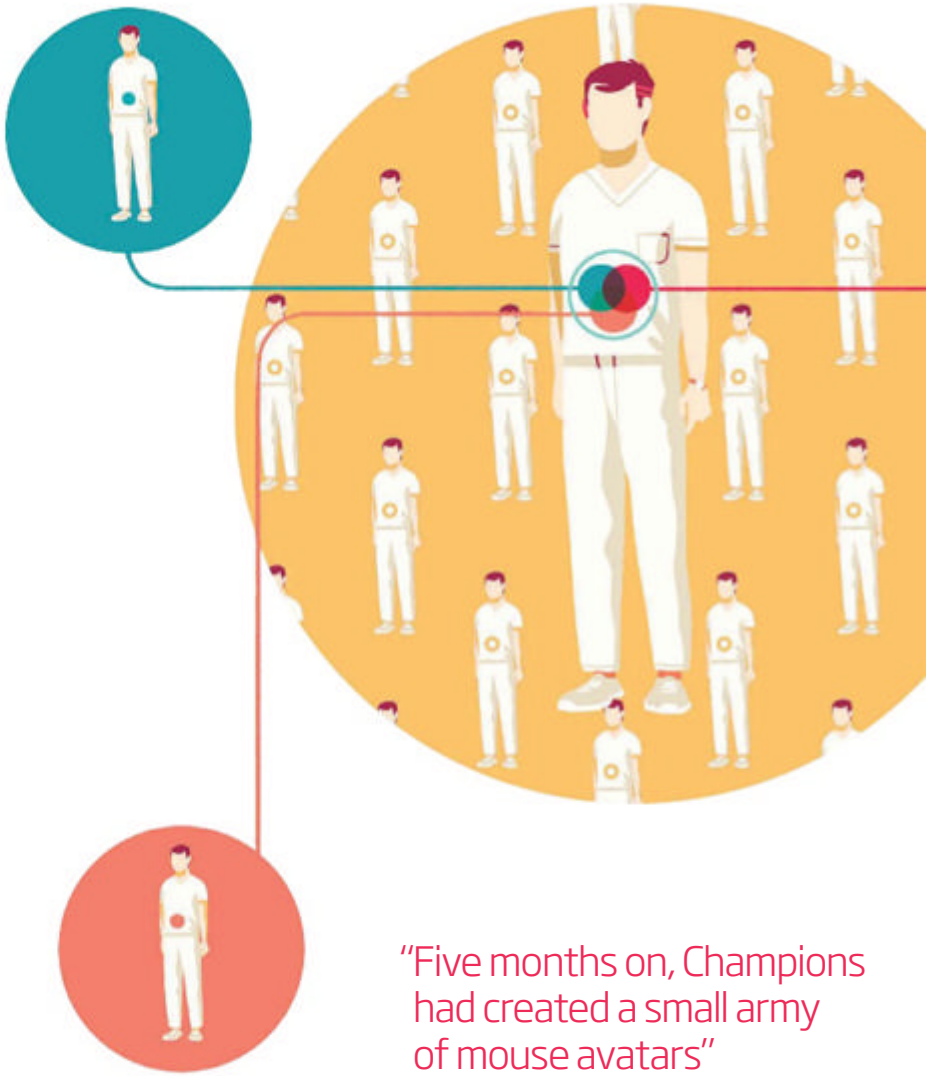
Getting personal

So the more closely treatment can be tailored to a person's particular cancer, the more effective it is likely to be. And personalised treatments are starting to become a reality. People whose tumours produce too much of a protein called Her2, for instance, are given specific drugs that work against this form of cancer. Genetic tests are also increasingly used to identify mutations known to affect how cancers behave. But while the field is advancing extremely rapidly, we are still far from the point where we can predict the best possible drug combination from genetic tests alone.

Indeed, there are reasons to doubt we ever will reach this point. The cells tested might not be representative of the whole tumour, for instance. What's more, the non-malignant cells in a tumour can have a big effect on the way it evolves and responds to treatment.

This, Morris says, is where Champions can help. "Building a very close replica of their tumour that's alive and continues to grow in a host environment gives patients the ability to simultaneously test four or five drugs or ›

TOM HAUGOMAT



combinations, so that they can see which is the most effective."

In late 2013, Crawford underwent chemotherapy and radiotherapy that shrank her tumour enough for surgeons to try and remove it from her pancreas. Her brother paid for a piece of the tumour to be cut up and implanted on the backs of several mice. After the tumours had grown somewhat, they were used to "infect" even more mice. Around five months on, Champions had created a small army of what cancer researchers call mouse "avatars". These were given combinations of drugs that genetic testing suggested might work to see which, if any, could shrink the tumours.

Champions says that the animals' suffering is minimal because the tumours grow just under the skin and don't invade organs. This was an important consideration for Crawford. "I know that animal testing is a sensitive subject, but when you find yourself in a position where you're reliant on it, you realise that it's quite vital," she says. "The only other option for me was to go through it all myself; I would be suffering pain, and my time might run out."

The process isn't cheap. Just creating the mouse avatars costs around £1500, and it doesn't always work on the first attempt; the success rate is around 70 per cent, Morris says. Then it's a further £2500 for each drug tested. Given that most patients opt to test four or five drugs, that's £11,500 to £14,000. Is it worth it?

Preliminary studies by Champions suggest that the mice's response to the cancer drugs does reflect what happens in the patient fairly well. In one study, 65 mouse avatars were given the same second- or third-line drugs as the people whose tumours they had received. According to a poster presentation given at a European Society of Medical Oncology meeting last year, there was an 87 per cent correlation between positive responses in mice and humans. "To put that in context, when a patient takes a second- or third-line drug, the chance of success is usually 10 to 15 per cent," says Morris.

Mouse avatars

The numbers may sound impressive, but this was a small study and the mouse avatars were not actually used to choose treatments. Other researchers would like to see more extensive testing of the approach before more people are persuaded to part with their cash.

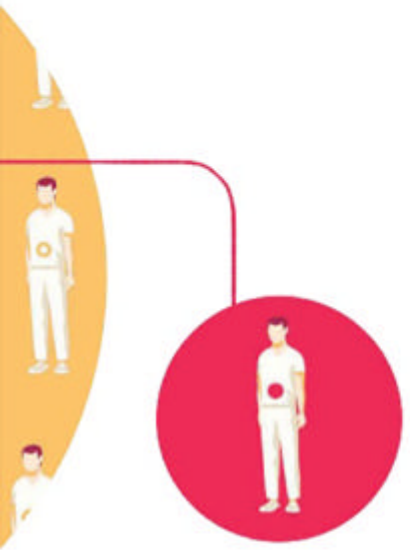
"Using avatar mice to try to predict patients' responses to treatment is an intriguing new approach to personalising medicine, but it's still at an experimental stage," says Emma Smith of Cancer Research UK. "It may be of benefit to some cancer patients in the future, but we'll need more research to determine if and for whom it might be helpful. In the meantime, it's vital that patients speak to their oncologist before deciding to pursue any experimental testing method."

Even those working in this field are cautious. Matthew Goetz at the Mayo Clinic in Rochester, Minnesota, who is investigating whether mouse avatars can help predict how women with breast cancer will respond to treatment, recalls what happened in the 1980s. "There were companies who claimed that they could figure out the right drugs for your ovarian cancer by growing the cancer cells in vitro and then looking at a potpourri of different drugs," he says. "Those studies were never really borne out or shown to be clinically useful, so I think we need to learn from that. We need to ask: 'What does this mean in the context of standard clinical practice?'."

Goetz, though, is optimistic about the long-term prospects for such patient-specific mouse avatars. One of the most useful applications could be for studying how resistance to cancer drugs evolves, both to identify the best treatments for individuals and to develop better treatments more generally. "A fundamental problem in the clinic is resistance to standard chemotherapy," he says. "If we can grow these tumours that are still viable after being bathed in 20 weeks of standard chemotherapy, and identify drugs that are active in them, I think the chances of those drugs then being successful in the clinic are much better."

But mouse avatars are far from perfect. A tumour growing under the skin of an immunodeficient mouse isn't the same as a tumour growing inside an organ under constant attack from a healthy immune system. The non-malignant cells in tumour xenografts also gradually become replaced with mouse cells. And with personalised treatments, one of the biggest problems is time. Someone with advanced cancer needs pointers to the best drugs for their tumour within

"Five months on, Champions had created a small army of mouse avatars"



weeks; in six months, they might be dead.

However, there may be a shortcut that also better reflects how malignant and non-malignant cells with a tumour interact. In recent years, tissue engineers have successfully constructed an array of complex tissues and organs, including bladders and windpipes. Now cancer biologists are using the same principles to reconstruct tumours and miniature models of the human tissues they colonise, from scratch.

At the Queensland University of Technology in Brisbane, Australia, they do this by first creating a polymer scaffold on which normal human cells are grown. At the same time, cancer cells are grown in a gel-like matrix to create a "spheroid" of tumour cells. Then the two are put together and implanted into a mouse.

> "One way or another, we will be cloning the cancers of many more people"

This process is much faster than growing chunks of a patient's tumour on a mouse's back, as Champions does. "Even the biggest spheroids we have in the lab take just two weeks to grow," says Daniela Loessner, who is leading the work. "It means we can have established tumours in mice within one month."

In theory at least, this approach is more likely to reflect how a tumour in a person would behave in response to drugs. It can even be used to study how cancer spreads, or metastasises. For instance, Loessner's team has been studying how ovarian cancer spreads to a tissue called the peritoneum by implanting a scaffold seeded with peritoneal cells and a spheroid of ovarian-cancer cells into a mouse.

"Metastases are often resistant to many of the standard cancer drugs, and this could enable us to test different drug combinations against them and find the ones that will benefit patients," Loessner says. They are not yet using this method to predict individuals' responses to drugs, but this is the ultimate goal of the group.

Another approach is to avoid the use of animals entirely, and grow tumours in a Petri dish instead. This would not only avoid the "yuck factor" of transferring someone's cancer to a batch of animals, but could also have other benefits for cancer patients seeking more personalised therapies. "In vitro would be cheaper, it would be more controllable, it would be faster," says Marilena Loizidou at University College London.

In an incubator in Loizidou's lab, tiny pink jelly beans of colorectal cancer are growing, barely visible to the naked eye. Like Loessner's engineered tumours, these blobs have been built by growing scaffolds of healthy human cells and cancer cells separately, and then combining them. Although the ability to grow cancer cells in 3D gels has been around for some time, incorporating healthy cells as well is very new, Loizidou says. "A lot of the behaviour of cancer and its responses to drugs has to do with the crosstalk between the cancer cells and the surrounding cells," she says. Indeed, the healthy cells that support the tumour's growth are beginning to look like an important target for cancer therapies in themselves.

It might not always be necessary to grow 3D tumours to get useful results. With the help of new techniques for growing cancer cells, for instance, a team at Massachusetts General Hospital recently tested dozens of drugs on 27 cell lines derived from people with drug-resistant lung tumours. They think the results are promising enough to try to develop the cell-line approach further.

However, the 3D approach is likely to deliver more useful insights. Cancer cells seem to grow better this way, and sometimes even show different responses to the same drugs. For instance, when Loizidou's group tested how colorectal cancer cells responded to a drug called cetuximab, which targets a protein on their cell surface, they found that the cells grown in 3D produced far more of this protein than standard cell lines, and yet despite this they were less responsive to the drug.

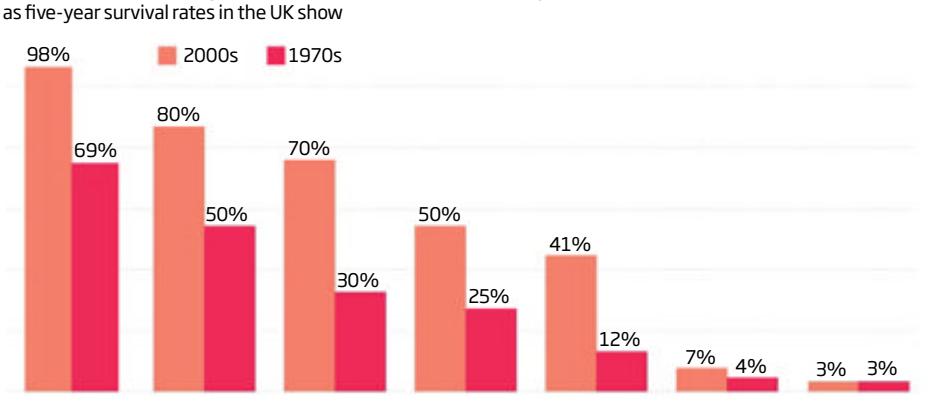
One way or another, then, it seems clear that we will be cloning the cancers of many more people in the future. Whether it is worthwhile for individuals to pay to have this done yet, though, is unclear.

Crawford, for instance, has not yet benefited directly. A series of post-surgical complications have made her too unwell to face further drug treatments at least for now, although on the bright side, there is currently no sign of her tumour returning. Nevertheless, for her the knowledge that the mouse avatars revealed several promising drug combinations is a source of great comfort and hope. "If I get struck again, there's at least a drug, or a couple of drugs that are likely to be effective," she says. "It means that I've got a fighting chance." ■

Linda Geddes is a consultant for *New Scientist*

Beating the Big C

More people are surviving cancer than ever before but for some types the odds remain poor, as five-year survival rates in the UK show

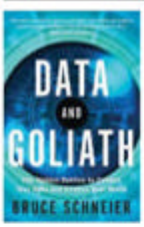


SOURCE: PDFORG.UK

Got you in our sights

Surveillance snuck up on society without anyone noticing. **Douglas Heaven** explores

Data and Goliath: The hidden battles to collect your data and control your world by Bruce Schneier, W. W. Norton, $27.95/£17.99



"DEAR subscriber, you have been registered as a participant in a mass disturbance." This text was sent by the Ukrainian government last year to everyone with a cellphone known to have been near a protest in the capital, Kiev.

Just what you'd expect from an ex-Soviet country? Not so fast. In the US and Europe, police are also seeking information on phones linked to specific places and times – and always without a warrant. We're all spied on. Our phones are bugged, our laptops inveterate informants. Reports on activities that define you – where you go, who you meet, what you buy – are sold to the highest bidder. But do we notice? And do we care?

Bruce Schneier does his best to make us do both. But it's tough: as it fades into the background, surveillance gets easier to ignore. For Schneier, this is a unique time to take a good look at the leviathan before it submerges forever.

So what is surveillance? The US military defines it as "systematic observation". It controls "what we see, what we can do... ultimately, what we say", says Schneier. A director of the Electronic Frontier Foundation in San Francisco, Schneier has been a go-to expert for years. He helped analyse some of the more technical documents leaked by Edward Snowden. But he wears his expertise lightly: the book moves fast and references are relegated to pages of notes.

GLEB GARANICH/REUTERS

There are brilliantly creepy examples. Take Cobham, a UK company that sells a system which allows "blind" calls to be sent to your phone. It won't ring, so you won't know you received it, but it makes your phone send a signal so callers can track it within a metre. Then there's Lower

"Spyware installed on laptops showed one student taking drugs in his bedroom. It was candy"

Merion School District in Ardmore, Pennsylvania, which installed spyware on laptops for its pupils. School administrators could secretly record chat logs, monitor web use and photograph the kids. This was exposed when a student was shown a picture of himself taking drugs. It turned out to be candy.

And image-based surveillance is poised to make things worse. Researchers at Carnegie Mellon University in Pittsburgh, Pennsylvania, set up a camera in a public space and identified people by combining face-recognition software with Facebook's publicly tagged database. By correlating names with other databases, they displayed data about individuals in the time it took them to pass by.

Many dismiss all this. Schneier cites a Google executive who told him that worrying about a computer reading your email was like worrying about your dog seeing you naked. It's not, Schneier rejoins: your dog won't base decisions on what they see, and will certainly never tell anyone.

Police worldwide are trying to link specific phones to specific events

Another common justification is that we're only giving up our metadata: the "to" and "from" of emails, not their contents; and the time and duration of calls, not what was said. It can still be highly revealing information and is the equivalent of someone tailing you and reporting who you spoke to and for how long, he says. And whatever's collected is stored indefinitely, often because it's cheaper and easier than filtering out the juicy bits.

Worse, what doesn't bubble to the surface today could do so tomorrow with new techniques. Take Alfred Kinsey's sex research subjects, who participated in the 1940s and 1950s only under the

strictest anonymity. In 2013, a study showed that in principle it would be possible to identify 97 per cent of them.

Snooping that once required a warrant and was subject to tight regulations is now routine. At one time, recounts Schneier, an FBI agent listening to a mobster on a bugged phone was required to stop listening when a spouse or child came on the line – quaint niceties compared to the practices of the US National Security Agency and the UK's GCHQ.

How did we get here? Fear – of terrorism in particular, says Schneier. But anti-terrorism laws suffer from mission creep and create a culture that normalises surveillance. How to get out of this is one of the big questions of our time, he adds.

So what can we do? Here, the impish anarchist in Schneier gets loose. Use the anonymising, ad-blocking, cookie-munching solutions available, he says, but also mess with the system: put stickers over laptop cameras, add noise to the data by searching for random names on Facebook, wear masks or face paint to confuse CCTV. He's only half joking. If data is the pollution problem of the information age, then protecting privacy is the environmental challenge. Can we make a difference?

Schneier calls himself a short-term pessimist but a long-term optimist. In 50 years, he says, people will look at today's data practices much as we now view practices like tenant farming or child labour. I'm not so sure. It may well be a generational issue, but not the way Schneier thinks. Few people under 30 worry where the data on their phone goes. Your feelings about Venmo, say – an app combining a digital-payment service with social-media updates on who you're paying – will also depend on age. And sexting is as common among teens as texting a decade ago. What if we look back at surveillance angst as a hang-up we had to overcome? ■

Tied to the land

Language grows from and with nature, finds **Benjamin Myers**

Landmarks by Robert Macfarlane, Hamish Hamilton, £20.00

The Fish Ladder: A journey upstream by Katharine Norbury, Bloomsbury Circus, £16.99

VOCABULARY is an ever-changing terrain, reshaped by tongue and trends, just as the elements and town planners reconfigure the landscape of Britain. And the relationship between place and name, argues Robert Macfarlane, is deep-rooted and undervalued.

"Language is fossil poetry," he writes, quoting 19th-century US essayist Ralph Waldo Emerson, and *Landmarks* is a project Emerson would have recognised: a "word-hoard". It attempts to preserve language and use it to pull us closer to our surroundings. This hoard is needed because specialised vocabularies are being burned off by apathy and urbanisation, says Macfarlane. In the mouths of the unimaginative, he reasons, generic language is shaping a "blandscape".

Landmarks serves as a convivial field guide to the authors who have inspired Macfarlane's magnificent writing: eco-philosophers such as John Muir, Roger Deakin and Nan Shepherd figure strongly. It has glossaries brimming with regional colloquialisms, from the poetically exact "ammil" – a term for the sparkle of morning sun through hoar frost – to the bawdy "wind-fucker", a kestrel.

The tenth glossary is left playfully blank, hungrily awaiting future words, because Macfarlane is no doom-monger. Words, he says, "act as a compass to sing [the land] back into being".

An ecologist, linguist and academic, Macfarlane is not above admitting his infatuation with Britain's diverse landscape. "Nature does not name itself," he writes. "Language is always late for its subject. Sometimes on top of a mountain I just say, 'Wow'."

In *The Fish Ladder*, her first book, Katharine Norbury cannot afford to be so ingenuous. How truthfully she writes will determine whether her series of river walks from sea to source will be seen as a sufficiently heroic quest.

"Specialised local vocabularies are being burned off by apathy and urbanisation"

Her project is driven by her miscarriage and subsequent depression, making this a book as much about grief and motherhood as about landscape.

There are moments of quiet drama, such as her waking on moorland to find a stag standing over her. Still, her journeys are not epic. She acknowledges the semi-industrial nature of her surroundings. Those fish ladders, for instance, are structures that allow fish to bypass dams, leaping barriers on the way to their spawning grounds. They allow salmon and hydroelectricity to co-exist.

Less happily, there is something touristic about her fleeting visits, and their meaning is occasionally overthought, as in "the fact we'd brought sandwiches seemed significant, somehow indicative of a need for self-sufficiency". She is only ever passing through.

The Fish Ladder is a valuable addition to the contemporary nature-memoir canon – although Norbury's life of second homes and Latin family mottoes highlights the irony that so few of today's memoirs about the natural world are written by those who work such harsh, remote lands. ■

Benjamin Myers is the author of the novel *Beastings*

PETER MARLOW/MAGNUM

Dyffryn Mymbyr in Wales, a chilly hotbed of poetic literature

Sausages of the Anti-Christ

Food is rarely the simple pleasure it once was, finds **Simon Ings**

Swallow This: Serving up the food industry's darkest secrets by Joanna Blythman, 4th Estate, £14.99
Appetites for Thought: Philosophers and food by Michel Onfray, Reaktion Books, £14.95/$24.95
Cravings: Can your food control you? Science Museum, London, until January 2016

SOME years ago, I was friendly with a family who ran a venison smokery. They were expanding their product line to include a venison salami. On one visit, they presented me with piles of sliced sausage: which recipe did I prefer?

My first mouthful was a disappointment. The sausage tasted of generic salami, hardly even of meat, and though I knew otherwise, it was hard to imagine that any deer had perished in the making of it. My second was just as bad. The body language of my hosts was revealing. My weak-beer praise simply confirmed what this conscientious family already knew: no tweaks were going to save their experiment.

As my friends discovered, you don't need to be a big food processor to hit big problems. Since mass production renders the best ingredients to tasteless slurry, your job is to rescue, recreate or, frankly, fake the tastes and aromas you killed off in making your product.

The keen home cook's first-aid kit includes fat, salt and sugar. But the food industry also uses (among many other extras) acids, enzymes, texturisers, blood plasma and grim-sounding powdered dairy essences. In *Swallow This*, the latest of a string of superior industry exposés, food journalist Joanna Blythman explains how far manufacturers will go to produce cheap foods that taste consistent, while retaining that "just-cooked" feel.

Her page about salami, for example, features company literature describing a meat glue made from the enzyme transglutaminase, blended with animal protein and vitamin B9: "Salami Dry Express B9 decreases ripening time by up to 20 per cent, creates a more… appealing colour in less time, offers improved casing peeling and… sausage aroma. Improved slicing properties reduce wastage by up to five per cent, while shorter processing and storage times also provide financial advantages."

Each promise listed sounds reasonable. But taken together, they suggest an approach to food that can only disgust consumers. And this, chiefly, is why the food processing industry is growing ever more secretive, ever more insincere, and, more worryingly still, ever more removed from the real science of nutrition. Its prime concern is not food, but keeping up appearances.

Everyone imagines they want an authentic home-cooked meal, even as they "require honeyed cakes, unguents and the like". This nice turn of phrase belongs to the Greek Cynic Diogenes, one of the philosophers in Michel Onfray's slim, sly volume of essays called *Appetites for Thought*. Rather in the spirit of *Bruces' Song*, Monty Python's dipsomaniacal summary of the Western philosophical tradition, Onfray dishes out morsels under chapter headings like "Nietzsche; or The Sausages of the Anti-Christ".

"Food processing is growing ever more secretive, more insincere, and removed from real nutrition science"

His simple thesis, that our minds are ruled by our stomachs, acquired a graphic reality in 2006, when Molly Smith, a 16-year-old from Cambridgeshire, UK, received a life-saving transplant. She had been born with much of her intestinal tract missing, and had never experienced hunger, thirst or any food cravings. When Molly finally ate her first solid food – a banana – she felt the stirrings of new sensations. Her guts were beginning to talk to her.

Molly's is one of the more startling stories told in Cravings, at London's Science Museum. The rich, mysterious, two-way dialogue between gut and brain that so entertained Onfray is its central theme, and serves as a playful entrée to health advice.

Though the exhibition is full of cautionary information about fat and sugar levels in many processed foods, it left this visitor hankering for the museum café. This is no bad thing. Food, any kind of food, is better than the alternative. And an exhibition about appetite ought to pique it. ■

Guts talk at an intriguing exhibition at London's Science Museum

JENNIE HILLS/SCIENCE MUSEUM, LONDON/SCIENCE & SOCIETY PICTURE LIBRARY

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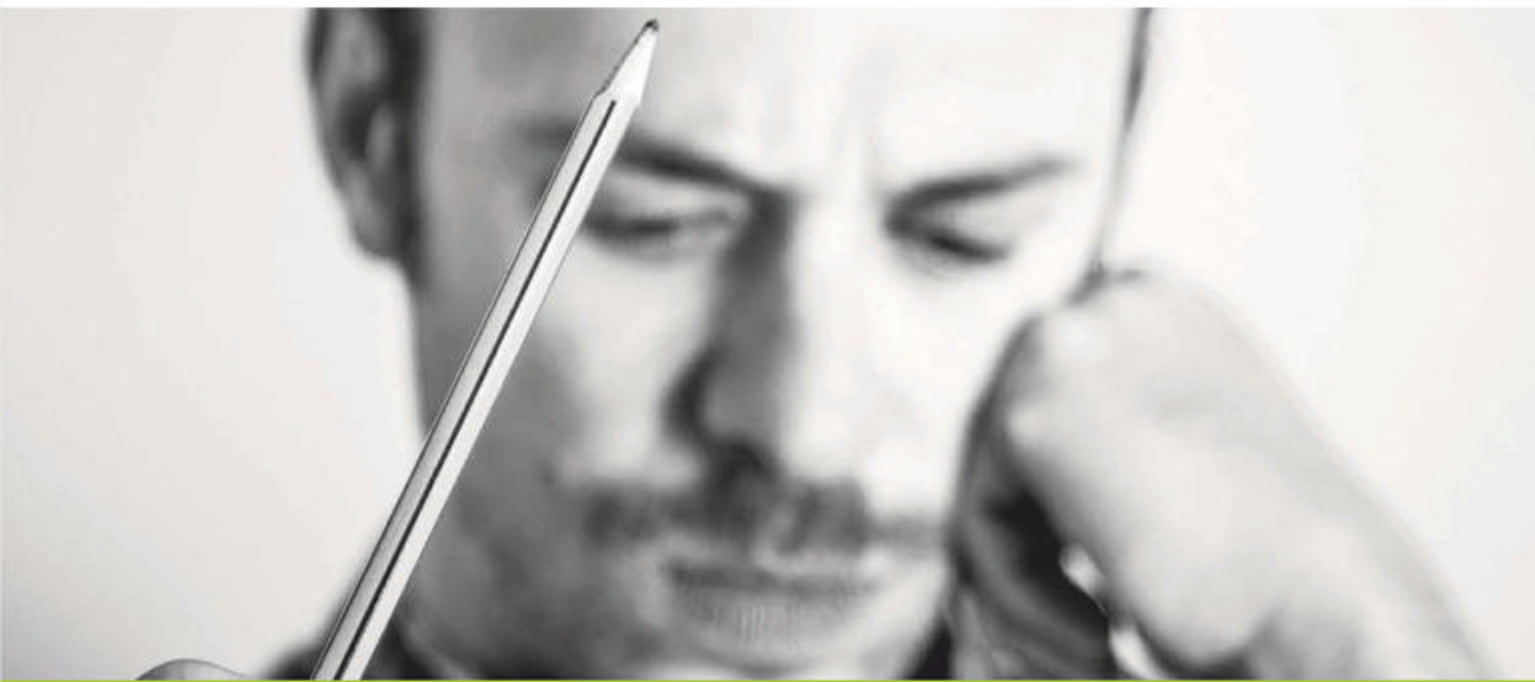

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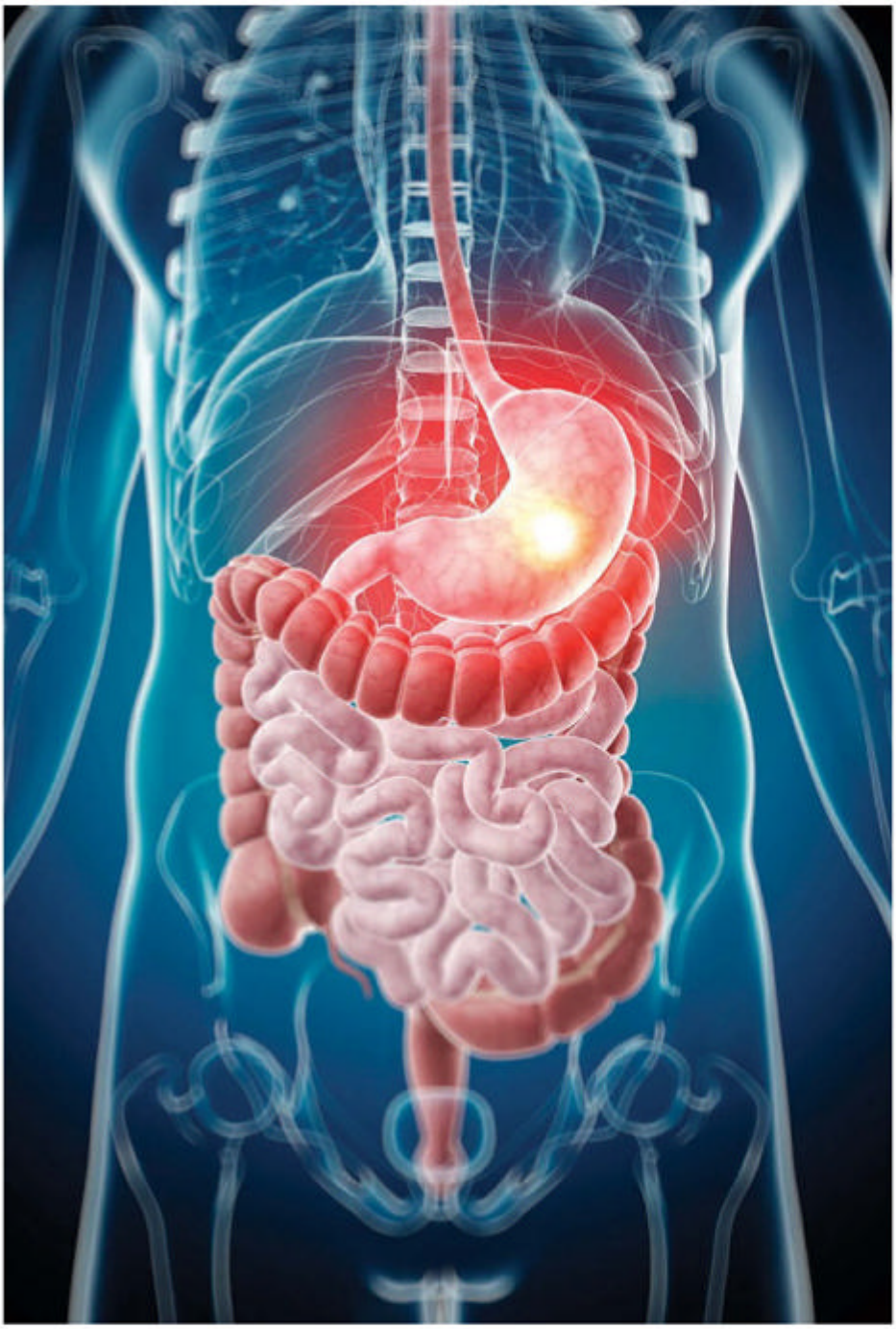

SEBASTIAN KAULITZKI/SCIENCE PHOTO LIBRARY

Here's looking at you

Microbiomes – we all have them. Jobs studying the microorganisms living inside us could be about to take off, offering a range of careers to all sorts of scientists. **Colin Barras** investigates

THE man had clearly been dead for some time, but there was no mistaking the stab wound in his badly decomposed chest. Step one in the homicide investigation: establish the victim's time of death. Bring in the microbiologists...

We've known for decades that the human body is home to a wide range of microbes, but within the past 15 years this human microbiome has come under the spotlight of scientific investigation like never before. We now recognize that our microbes can play a vital role in the battle against some lethal pathogens and, potentially, some cancers; that they can tell us about our evolutionary past; and that they could even help criminal investigators establish the basic facts in an investigation. All of which means there are more career opportunities than you might think in studying the bugs that call the human body home.

Under our noses

There's a simple and perhaps surprising reason why the human microbiome went unstudied for so long: in common with many microbes, those that live in our bodies are extremely difficult to grow in the lab and equally difficult to study.

Then, a little over a decade ago, things changed. New DNA sequencing technology emerged that was sensitive enough to probe the genetic composition of individual microbes in samples, offering a way to study them without first growing them into large cultures. "It sidesteps the problem," says Lita Proctor at the National Institutes of Health in Bethesda, Maryland, and program director of the NIH's Human Microbiome Project, a $200 million effort to explore the link between our microbes and our health.

The cost of that sequencing technology has now fallen so dramatically that almost anyone can study the microbes in our bodies and our environment – and many individuals are, through 'citizen labs' that have begun popping up across the US. "People with no formal training can sequence DNA now – it's completely in reach of everybody," says Proctor.

A typical example of that is Alex Khoruts. He began his research career as a cellular immunologist before moving into digestion. When he began his gastroenterological research, the consensus was that the microbiome in the human gut doesn't really

change during our lives, meaning there's little to be gained from trying to manipulate it. Five years ago, Khoruts and his colleagues at the University of Minnesota Medical School in Minneapolis used DNA sequencing technology to show that this thinking was wrong. They found that they could "graft" new microbes onto someone's existing gut microbiome by transplanting fecal material

"People with no formal training can sequence DNA now"

from a healthy donor into the patient's colon. The technique offered a highly effective way to treat people infected with the deadly superbug *Clostridium difficile*, which can wipe out significant chunks of the gut microbiome.

It was a clear sign that microbiome research is about more than sating scientific curiosity. "Human lives were being saved by microbes," says Khoruts. "It was great PR for this research area."

There is growing evidence too that obesity can be triggered by imbalances in the gut microbiome, which has led some to suggest the condition might be treated with fecal transplants. The same sort of transplants might one day be offered to treat some forms of cancer too, particularly as evidence mounts that certain forms of the disease – particularly colorectal cancer – are associated with unusual abundances of particular gut microbes.

Picking your path

For researchers who can think outside the box, there's almost no end to the microbiome research options available, says Jessica Metcalf, an evolutionary biologist at the University of Colorado Boulder (CU-Boulder). She says that because the sequencing tools already exist, the secret to carving out a successful niche, in research especially, is to think up ingenious new ways of using them (see "Out of this world").

The challenge for young scientists keen to study microbiomes is to get ahead of the curve, and that's tough while the science is so new. "For new knowledge from cutting-edge research to percolate down to medical school takes about a decade," says Khoruts, but students can seize the initiative by asking their professors for information. "At my university, we offer extracurricular lectures in the subject," he says.

Young researchers might also benefit from online courses, such as Gut Check, launched last year at CU Boulder to provide a basic education in human microbiome research.

Rob Knight – who recently moved from CU Boulder to the University of California in San Diego – taught the course with Metcalf and Katherine Amato, and while it was focused at members of the public, students would benefit too. "There are many companies launching in the microbiome space at the moment, and tremendous demand for people trained in those topics," he says.

Indeed, private enterprise offers the best opportunities for study right now, as Proctor explains that difficult economic times have seen government medical research budgets frozen. "It's a really tough

"Microbiome research could help combat superbugs, obesity and cancer"

time, even though we have this exciting new discipline emerging," she says.

Government's loss is industry's gain, "especially because of the microbiome links to obesity, cancer and cardiovascular disease," says Christian Jobin at the University of Florida in Gainesville, who studies the link between bacteria and various diseases of the gut. He says that enterprising businesses that recognize the potential profits in developing new microbiome-tweaking therapies to treat common diseases will soon be looking for researchers to help develop those therapies.

What's more, microbiome studies aren't restricted to medicine. In 2010, a team led

"There are many companies launching in the microbiome space at the moment"

by Knight discovered that we each leave a unique and distinct bacterial trace on the computer keyboards we use, hinting that microbiome research might have applications in forensic sciences.

In 2013, Knight and Metcalf studied the way that the microbiome of mice changes after the animals die. Funding for the research came from the US Department of Justice, as the shifts in the microbial community compositions are so strong and predictable that if they are seen in humans too, they could form the basis of a "clock" to estimate time of death to within a few days, even for corpses that go undiscovered for a couple of months.

When it comes to serving justice, microbiologists could well prove to be the cops' best friend. ■

Colin Barras is a writer based in Ann Arbor, Michigan

OUT OF THIS WORLD

WHEN Scott Kelly begins a year-long mission on the International Space Station later this month, one of the most unusual microbiome studies yet devised will get under way. Scott's identical twin and fellow astronaut, Mark Kelly, will remain on the ground. By analyzing samples both brothers provide, researchers hope to discover how space travel affects the human microbiome.

Those findings will be of interest to NASA as it considers launching crewed missions to Mars, but there could be implications for those of us who never leave the planet. "If astronauts get sick every time the microbiota [the microbes in your gut] shifts in a certain way that definitely has implications for understanding similar microbiota shifts back on Earth," says Martha Hotz Vitaterna of Northwestern University in Evanston, Illinois, who is involved in the study.

Vitaterna and her colleague, study leader Fred Turek, are best known for their work on sleep and circadian rhythms. Like many microbiome researchers, they stumbled into the field almost by accident – about ten years ago, they began collaborating with gastroenterologists at Rush University in Chicago. "They came to us saying, 'We think some gut diseases are actually circadian,'" says Vitaterna. "We've now published a lot of papers on circadian rhythms, sleep and gastrointestinal function, including dysbiosis."

That joint background means Vitaterna and Turek have twice as much to gain from the astronaut microbiome research. "It's hard to imagine a less formal circadian environment than being off the planet," says Vitaterna.

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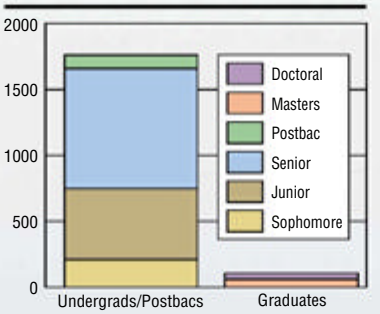
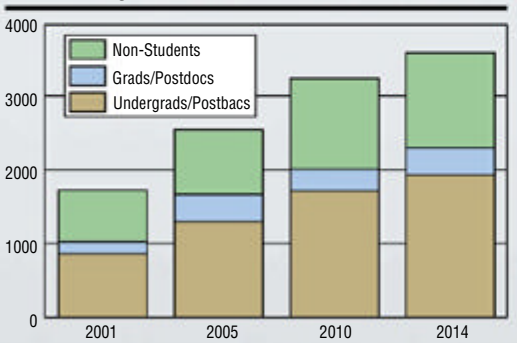
2014 Abstract Submissions by Education Level



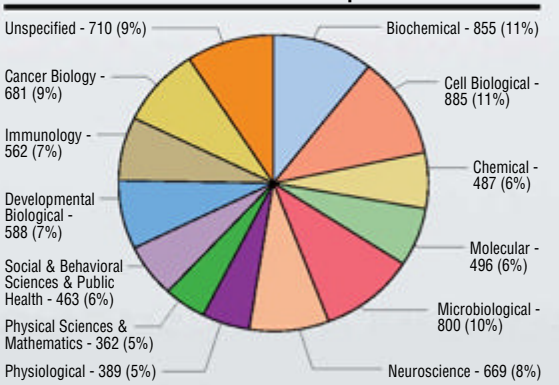
2014 ABRCMS Attendees by Location

ABRCMS Registration



"It was a great opportunity to see the extraordinary research being conducted in the country and also to encourage and offer thoughtful advice to the future scientists."
FACULTY/JUDGE

2014 Distribution of Scientific Disciplines



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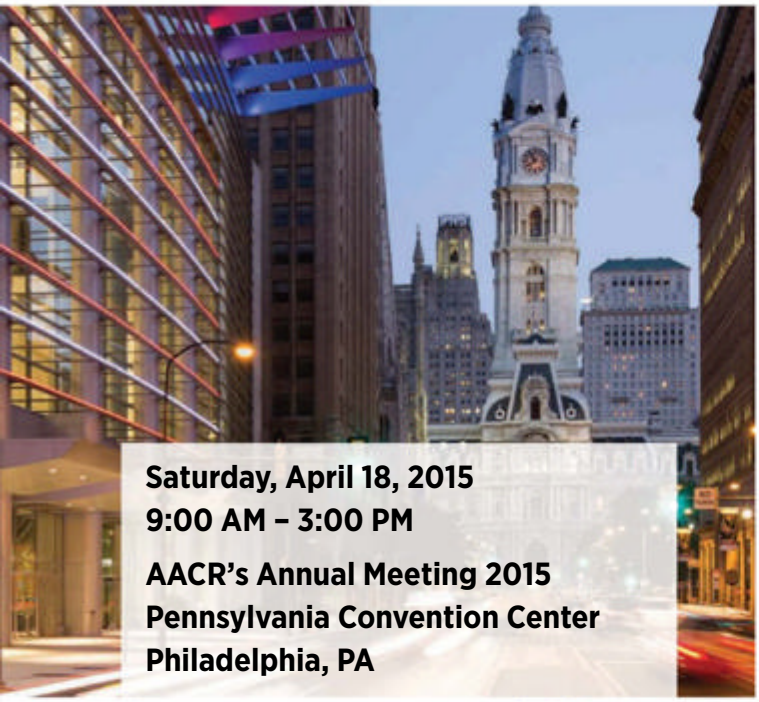

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Technical/Research Assistants

The Koch Institute for Integrative Cancer Research, a National Cancer Institute (NCI)-designated Cancer Center, is a state-of-the-art cancer research facility as well as the hub of cancer research on the MIT campus. The Koch Institute (KI) brings together biologists and chemists along with biological, chemical, mechanical, and materials science engineers, computer scientists, clinicians and others, to bring fresh perspectives and an interdisciplinary approach to advancing the fight against cancer. This multi-faceted group of investigators is at the core of the Koch Institute's mission to develop new insights into cancer, as well as new tools and technologies to better treat, diagnose and prevent the disease.

The KI has several exciting Technical/Research Assistant positions open now and in the coming months. These positions are critical to our mission, supporting and enhancing cutting-edge, interdisciplinary, cancer-focused scientific/engineering projects. We are looking for individuals who value creativity, diversity, inclusion, and collaboration. Why not be part of a supportive community that fosters personal and professional development? Once you're here, you'll want to stay.

As a Technical Assistant, you will be part of a dynamic team and will provide technical expertise and support by: organizing and completing experiments and tests by studying project objectives and processes; documenting results; keeping project leader informed; maintaining equipment; maintaining and a safe and healthy work environment; completing experiments and tests; performing protocols; updating job knowledge; exploring opportunities to add value to job accomplishments.

Minimum Qualifications: BS in Biological Sciences or other relevant field; hands-on experience in research laboratory environment; experience informing superiors and peers based on their information needs; committed to exceeding quality standards and providing exceptional services; exhibits meticulous attention to detail; committed to producing accurate and high-quality work; practiced documentation skills; uses multiple resources, quantitative, and qualitative research methodologies to capture and interpret information; aware of basic safety issues; follows safety procedures and maintains a safe work environment; trained in hands-on equipment maintenance.

MIT is an equal employment opportunity employer. All qualified applicants will receive consideration for employment and will not be discriminated against on the basis of race, color, religion, sex, sexual orientation, gender identity, national origin, veteran status, or disability.

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KOCH INSTITUTE
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UTSA® The University of Texas at San Antonio

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The Department of Chemistry at The University of Texas at San Antonio (UTSA) seeks internationally renowned scientists to fill two newly established Robert A. Welch Endowed Chairs in Chemistry. The research area of one Chair is expected to encompass the interface of chemistry and biology. The research area of the other Chair can encompass any area of modern chemistry. Each Welch Chair includes a generous endowment, a highly competitive salary, and ample modern research space. Significant additional financial resources and state-of-the art facilities are available. The scientists occupying these Welch Chairs are expected to play leadership roles in ongoing departmental growth and faculty recruitment. Opportunities are available for collaborative initiatives at UTSA and with nationally renowned area institutions, including the University of Texas Health Science Center at San Antonio and the Southwest Research Institute.

San Antonio is the 7th largest city in the U.S. and features a historical and vibrant downtown area. UTSA is located northwest of downtown San Antonio adjacent to the scenic Texas Hill Country, which provides many recreational opportunities.

Nominations and inquiries can be sent to the Department Chair, Dr. Waldemar Gorski, at the following address: Department of Chemistry, UTSA, One UTSA Circle, San Antonio, TX 78249 or via email (**Waldemar.Gorski@utsa.edu**).

MS in Bioinformatics at Boston University

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Now awarding MS Merit Scholarships, providing tuition assistance to full-time students on a competitive basis

The Master's degree requires a total of 32 credits. You can complete the program in as little as 18 months, or enroll part-time for a schedule that fits your lifestyle. BU Bioinformatics offers an MS degree in Bioinformatics, or an MS in Bioinformatics with a focus on Translational Medicine

Application Deadlines:
July 1 for fall | December 15 for spring

bu.edu/bioinformatics/

BOSTON UNIVERSITY

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1401555997	Research Associate I (209959), Bethesda, Maryland. **HENRY M JACKSON FOUNDATION**
1401556256	Postdoctoral Appointee - Coherent Imaging, Lemont, IL **ARGONNE NATIONAL LABORATORY**
1401546598	NASA Postdoctoral Program (NPP) - **OAK RIDGE ASSOCIATED UNIVERSITIES**
1401557328	Postdoctoral position in The Section on DNA Helicases - Baltimore, MD **NATIONAL INSTITUTES ON AGING (NIA)**
1401556624	Postdoctoral Fellow Opportunities - Geisinger Translational and Molecular Medicine Program **GEISINGER HEALTH SYSTEM (GHS)**
1401549261	Postdoctoral Fellow, Molecular Biology (Job Id 20484) - Danville, PA **GEISINGER HEALTH SYSTEM (GHS)**
1401557338	Postdoctoral Research Associate - Seattle, WA **BENAROYA RESEARCH INSTITUTE**
1401552635	Research Fellow, Wagle Lab- Boston, MA **DANA-FARBER CANCER INSTITUTE**
1401559132	Post-Doc Research Fellow, Multiple Myeloma- Boston, MA **DANA-FARBER CANCER INSTITUTE**
1401555504	Postdoctoral Fellowship, Neurobiology - Boston, MA **BOSTON CHILDREN'S HOSPITAL AND HARVARD MEDICAL SCHOOL**
1401557337	Postdoctoral Positions - New York, NY **MOUNT SINAI SCHOOL OF MEDICINE**
1401555439	Postdoctoral position in Molecular Neuroscience, LSU - New Orleans, Louisiana **LSU HEALTH SCIENCES CENTER, NEUROSCIENCE CENTER OF EXCELLENCE**
1401555292	Postdoctoral Position at Purdue University's Birck Nanotechnology Center - West Lafayette, IN **PURDUE UNIVERSITY**
1401556261	Postdoctoral Research Associate in MicroBooNE and Mu2e - Manhattan, KS **KANSAS STATE UNIVERSITY, DEPARTMENT OF PHYSICS**
1401550138	Postdoctoral Recruitment Day "Summer Preview" is June 4-5 in Ann Arbor, Michigan **UNIVERSITY OF MICHIGAN MEDICAL SCHOOL (UMMS)**
1401546596	Postdoctoral Positions - **UNIVERSITY OF ALABAMA AT BIRMINGHAM (UAB), OFFICE OF POSTDOCTORAL EDUCATION**
1401487465	Opportunities at Lerner Research Institute - **CLEVELAND CLINIC FOUNDATION, LERNER RESEARCH INSTITUTE**
1401545856	Faculty and Postdoc Opportunities - **UNIVERSITY OF CALIFORNIA, IRVINE**
1401546595	Grant Programs for Scientific Research and Teaching - **BURROUGHS WELLCOME FUND**
1401557687	Postdoctoral opportunity in Translational Oncology **ASTRAZENECA US**
1401557067	Postdoctoral Opportunity in Cellular Signaling Dynamics, Translational Safety **ASTRAZENECA US**
1401557066	Post Doctoral Opportunity-Neuroscience, USA **ASTRAZENECA US**
1401557065	Post Doctoral Opportunity - Discovery Sciences, Waltham USA **ASTRAZENECA US**
1401557063	Postdoctoral Opportunities in Discovery Sciences (Structure & Biophysics and Chemical Biology) **ASTRAZENECA US**
1401557062	Post Doctoral Opportunity Oncology iMED, Boston, USA **ASTRAZENECA US**
1401557059	Post Doctoral Opportunities in Drug Safety, Boston USA **ASTRAZENECA US**
1401557057	Post Doctoral Opportunity, Neuroscience, Baltimore, USA **ASTRAZENECA US**
1401556910	Postdoc in Stem Cell Biology/Neuroscience **ASTRAZENECA US**
1401556789	Post Doctoral Opportunity - Oncology NGS Bioinformatics, USA **ASTRAZENECA US**
1401555611	Research Associate, Biotherapeutics Job **CELGENE**
1401553672	Research Associate, Biotherapeutics Job - San Diego, CA **CELGENE**
1401557430	Research Associate IV **THERMO FISHER**
1401560815	Post Doctoral Opportunity - Oncology NGS Bioinformatics, USA **ASTRAZENECA US**
1401560446	Post Doctoral Research Fellow B Cell Response to Vaccination **FRED HUTCH**
1401559818	Post Doctoral Research Fellow Viral Infection Modelling **FRED HUTCH**
1401559816	Post Doctoral Research Fellow **FRED HUTCH**
1401559802	Statistical Research Associate I II **FRED HUTCH**
1401559772	Statistical Research Associate I III **FRED HUTCH**
1401559739	Post Doctoral Research Fellow Physics Engineering and Biology **FRED HUTCH**
1401559725	Post Doctoral Research Associate Cancer Drug Therapy Discovery Applying Functional Genomics **FRED HUTCH**
1401559668	Post Doctoral Research Fellow Molecular Analysis of Transcriptional Regulation **FRED HUTCH**
1401559761	Post Doctoral Research Fellow Computational Biology **FRED HUTCH**
1401559798	Post Doctoral Research Fellow Transplant Immunology **FRED HUTCH**
1401559773	Post Doctoral Research Fellow Immunobioengineering **FRED HUTCH**
1401559814	Post Doctoral Research Fellows Quantitative Infectious Disease Methods **FRED HUTCH**
1401559817	Post Doctoral Research Fellow Humoral Immunity to Vaccines and Infection **FRED HUTCH**

California Polytechnic State University
TENURE TRACK POSITION
ORGANIC CHEMISTRY OR BIOCHEMISTRY

CAL POLY
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Teaching assignments will be in organic chemistry or biochemistry with substantial assignments in general chemistry for majors and non-majors. The successful candidate will be expected to play a role in pedagogy and curriculum development for our chemistry offerings. We encourage applications from candidates who plan to incorporate this curriculum activity into their research program. Successful candidates must be committed to high-quality undergraduate education and will be expected to develop and maintain an active undergraduate research program. Publishable research that engages undergraduates is expected. Salary and rank are commensurate with qualifications and experience. Appointment is anticipated at the assistant professor level, but appointment at an advanced level may be possible for a highly experienced candidate.

A Ph.D. in biochemistry, chemistry, or related discipline is required at the time of hiring. Area of research specialization is open but specializations in organic chemistry or biochemistry are preferred. The Department of Chemistry and Biochemistry offers B.S. degrees in both chemistry and biochemistry. The department also serves many technical programs in the University. Students may choose concentrations in Polymers and Coatings, Molecular Biology, or a focused Master's program in Polymers and Coatings Science. The department is committed to providing each student with a capstone experience through a faculty-facilitated senior project. More information may be viewed at **http://www.calpoly.edu/~chem**.

To apply, go to **WWW.CALPOLYJOBS.ORG** and complete a required online faculty application and submit to requisition #103595. Applications must include: online application form, cover letter addressing the appropriate qualifications listed above, current resume, statement of teaching philosophy, a proposal for scholarship, and evidence of successful teaching. These and other materials such as syllabi can be attached as PDF documents to the online form. Please be prepared to provide three professional references with names and email addresses when completing the on-line application.

Screening of applicants begins April 20, 2015; complete applications received after that date may be considered. Finalists will be required to submit a 10-minute video sample of their teaching. The topic for the video will be "Equilibrium," and the target audience will be freshmen in a year-long, science-majors general chemistry course. Preliminary telephone interviews will be held in late April and finalists asked to interview in May, 2015 for a starting date of September, 2016. Official transcripts will be required prior to an appointment.

For questions, please contact Dr. Nanine Van Draanen at **nvandraa@calpoly.edu**.

At California Polytechnic State University, San Luis Obispo, we believe that cultivating an environment that embraces and promotes diversity is fundamental to the success of our students, our employees and our community. Bringing people together from different backgrounds, experiences and value systems fosters the innovative and creative thinking that exemplifies Cal Poly's values of free inquiry, cultural and intellectual diversity, mutual respect, civic engagement, and social and environmental responsibility. Cal Poly's commitment to diversity informs our efforts in recruitment, hiring and retention. California Polytechnic State University is an affirmative action/equal opportunity employer. EEO.

UAB THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Postdoctoral Positions

The University of Alabama at Birmingham (UAB) is one of the premier research universities in the US with internationally recognized programs in AIDS & bacterial pathogenesis, bone biology & disease, cancer, diabetes & digestive & kidney diseases, free radical biology, immunology, lung disease, neuroscience, trauma & inflammation, and basic & clinical vision science among others. UAB is committed to the development of outstanding postdoctoral scientists and has been consistently ranked in recent years as one of the top locations among US universities for training postdoctoral scholars.

UAB is recruiting candidates for postdoctoral positions in a variety of research areas. UAB faculty are well funded (top 25 in NIH funding), utilize multidisciplinary approaches, and provide excellent research training environments that can lead exceptional candidates to entry level positions in academia, government or the private sector. Full medical coverage (single or family), competitive salaries/stipends, sick leave, vacation, and maternity/paternity leave are offered with every position as well as AD& D, disability & life insurance. Depending on the source of funding, retirement benefits may also be available. Birmingham is a mid-size city centrally located in the southeast near beaches and mountains and enjoys a moderate climate for year round outdoor activities and a cost of living rate lower than most metropolitan areas.

Visit our website at **www.uab.edu/postdocs/openings**, to view positions. See info also on MERIT Program, an NIH IRACDA program. Send your CV to the contact name for the positions that you are interested. University of Alabama at Birmingham, Office of Postdoctoral Education, 205-975-7020.

UAB is an equal employment opportunity employer.

Bates College,
Faculty Position, Biology

Visiting Assistant Professor of Evolution and Conservation Biology - Biology R2706

Location: **Lewiston, Maine**

The Biology Department of Bates College invites applications for a 1-year, full-time faculty position in evolutionary biology and conservation biology, beginning 1 August 2015. Teaching responsibilities comprise five courses per year, including an upper-level evolution course, a conservation biology course, two offerings of an entry-level evolution course open to all majors, and an additional course related to conservation biology or environmental studies. Supervision of undergraduate thesis research is also expected.

Qualifications

PhD or ABD required by start date. We welcome applications from all individuals with the ability to contribute to the college's continuing commitment to social and cultural diversity, inclusiveness, and the transformative power of our differences. The search committee asks applicants to identify their strengths and experiences in these areas and describe how their research, teaching, and/or outreach can further this goal.

Application Instructions

Review of applications begins 15 March 2015, and will continue until the position is filled. Applicants should submit in PDF format, a cover letter, curriculum vitae, unofficial graduate transcripts, and statements on teaching and research. Please also arrange for the submission of three letters of recommendation, in PDF format. Employment is contingent upon successful completion of a background check.

Please email **academicservices@bates.edu** for further consideration, and don't forget to mention you saw us in New Scientist Magazine.

60 Years of Advancing Biomedical Research

Biomedical research is usually an incremental endeavor. The result of one experiment may be a small but critical part of a thread that ultimately leads to a resolution of a more complex problem. The inability to predict which experiments will set the trajectory to a major discovery or even a cure presents a unique challenge to funding organizations as we try to determine our investments. Rather than focus on the projects themselves, we choose to focus on the individuals we deem the most promising, giving them the chance to make critical, incremental, and sometimes major insights in understanding. We know that it is difficult to anticipate all the necessary discoveries and approaches or to guarantee a precise timeline for success. By providing flexible funding to talented and motivated individuals, we enable the risk-taking often needed to advance research and understanding.

Although we fund individual researchers, we recognize that interdisciplinary, collaborative interactions make important contributions to advance understanding of complex problems. Many of the big questions left in science now exist beyond the traditional disciplinary borders. To help address these questions, we are encouraging collaboration through activities such as our annual networking meeting, travel grants that introduce investigators to new techniques, the population and laboratory based sciences program, and our interfaces career awards. We want different approaches and perspectives to be brought to bear on problems that are often too difficult for one individual or discipline to solve.

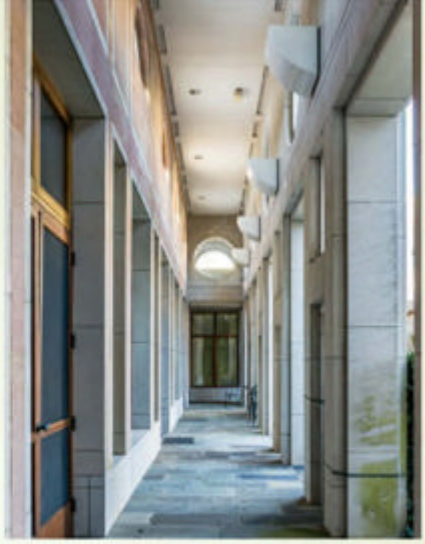
We also recognize that the education of all members of society is integral to the long-term health and success of biomedical research. Young people, in particular, need strong preparation in science and mathematics, not only to prepare them for job success, but also to arm them with the intellectual skills necessary to solve problems of all types throughout their lives. An educated public can better understand the importance of biomedical research and, in these tight economic times, can help provide the support needed for research funding. We coordinate a number of programs in education to get the next generation excited about science and math and perhaps encourage them to pursue a career in those fields. Even if they don't become scientists, we hope they will better understand and support scientific endeavors.

We are quickly approaching our 60th anniversary and we at the Burroughs Wellcome Fund remain confident that by investing in education and promising innovative researchers who ask critical questions, we will help advance biomedical research to the benefit of all.

John E. Burris, Ph.D.
President
Burroughs Wellcome Fund

"By providing flexible funding to talented and motivated individuals, we enable the risk-taking often needed to advance research and understanding."

For complete program information, including deadlines, please visit www.bwfund.org



Grant Programs

BIOMEDICAL SCIENCES

Career Awards for Medical Scientists: Five-year awards for physician scientists provide $700,000 to bridge advanced postdoctoral/fellowship training and the early years of faculty service. This award addresses the on-going problem of increasing the number of physician scientists and will help facilitate the transition to a career in research.

Collaborative Research Travel Grants: Provide up to $15,000 in support for interdisciplinary biomedical researchers from degree-granting institutions to travel to a laboratory to acquire a new research technique or to facilitate collaboration.

CAREER GUIDANCE

Career Guidance for Trainees: Provides up to $50,000 over a one-year period to support demonstration projects that will model affordable approaches to improving trainees' readiness for stable, fulfilling careers.

DIVERSITY IN SCIENCE

Postdoctoral Enrichment Program: Provides $60,000 over three years to support the development of underrepresented minority postdoctoral fellows in biomedical research.

INFECTIOUS DISEASES

Investigators in the Pathogenesis of Infectious Disease: Five-year awards provide $500,000 for opportunities for accomplished investigators at the assistant professor level to study infectious disease pathogenesis, with a focus on the intersection of human and microbial biology. The program is intended to shed light on the overarching issues of how human hosts handle infectious challenge.

INTERFACES IN SCIENCE

Career Awards at the Scientific Interface: Five-year awards provide $500,000 to bridge advanced postdoctoral training and the early years of faculty service. These awards are intended to foster the early career development of researchers with backgrounds in the physical/mathematical/computational/engineering sciences whose work addresses biological questions.

REGULATORY SCIENCE

Innovation in Regulatory Science Awards: Provides up to $500,000 over five years to academic investigators developing new methodologies or innovative approaches in regulatory science that will ultimately inform regulatory decisions.

REPRODUCTIVE SCIENCE

Preterm Birth Initiative: Provides $600,000 over a four-year period to bring together a diverse interdisciplinary group with the more traditional areas of parturition research to address the scientific issues related to preterm birth.

SCIENCE EDUCATION

Career Awards for Science and Mathematics Teachers: Five-year awards provide $175,000 to eligible science or mathematics teachers in the North Carolina public primary and secondary schools. The purpose of this award is to recognize teachers who have demonstrated solid knowledge of science or mathematics content and have outstanding performance records in educating children. The award is a partnership between the North Carolina State Board of Education and BWF.

Student Science Enrichment Program: Three-year awards provide up to $180,000 to North Carolina nonprofit organizations, including public/private schools, universities, colleges, and museums. This program supports creative inquiry-based science enrichment activities that occur outside the typical school day for K-12 students. The program's goals are to nurture students' enthusiasm about science, expose them to the excitement of scientific discovery, and interest them in pursuing careers in research or a variety of other careers in science.

Promoting Innovation in Science and Mathematics: Awards up to $4,500 provide teachers with funding for materials, equipment, and training to conduct hands-on, inquiry-based science and mathematics projects in North Carolina public schools.

The Burroughs Wellcome Fund is a private foundation located in Research Triangle Park, North Carolina. Find out more at **bwfund.org**

BURROUGHS WELLCOME FUND

Wheely good odds

From James Ferguson
In your exploration of chance, you state that the probability of 26 consecutive black numbers in roulette is 1 in 136,823,184, and mention this happened in Monte Carlo in 1913, as if that was somehow surprising (14 March, p 28). What is surprising is that this doesn't happen more often.

There are some 3500 legal casinos worldwide. If we assume there are only two roulette wheels in each casino on average, that each is only used for 6 hours a day and spun 35 times an hour, then each year we see 537 million spins.

If a black followed by 25 more blacks should happen once in every 137 million spins, it should happen somewhere on the globe every three months.

Either the probability calculation is flawed or we have just uncovered a significant bias in the world's roulette wheels.
London, UK

From James Stone
Regina Nuzzo suggests that choosing between Bayesian and frequentist methods of probability is "horses for courses" (p 38). Like choosing to get home by taking the Bayesian bus or the frequentist train; both will get you there, but via different routes. It is not so.

In essence, a Bayesian estimates the probability that a hypothesis is true based on observed data values. In contrast, a frequentist estimates the probability that data values, equal to or more extreme than those observed, would occur, based on the assumption that a null hypothesis is false.

As Harold Jeffreys noted, one result of this convoluted reasoning is that, "a hypothesis that may be true may be rejected because it has not predicted observable results that have not occurred." Bus or train? That depends on where you want to get to.
Sheffield, UK

Under covers

From Alison Dando
Sumit Paul-Choudhury's interesting review of *The Nether* (14 March, p 44), a play which examines the morality of a virtual clubhouse for paedophiles, got me thinking.

What about books with content that I find horrible and offensive? If people are to be prosecuted for their imaginations, and for indulging in their fantasies in a way that does no harm to others, where do you draw the line between a computer's virtual reality and a book's virtual reality?

Do we revert to the times when books were banned for their content? People will always use their imaginations, in private if not in public, so the best we can probably hope for is to channel any potentially harmful thoughts in ways harmless to others, only prosecuting if it can be shown that such bounds have been exceeded.

Surely censorship should be for the guidance of the user and protection of unwilling participants, not to impose the moral standards of some people onto everyone else. The long shadow of fundamentalism looms in that direction!
Temple Sowerby, Cumbria, UK

Getting ahead

From Hilary M. Gee
I read the various comments on proposed head transplants with interest (14 March, p 54). Even if such transplants are desirable and the spinal cord can be successfully reconnected, no one has mentioned the autonomic nervous system. Parts of this run outside the spinal column and are important in regulating a variety of internal processes including heart rate, constriction of the airways in the lungs, assorted gut activities and bladder function.

If the vagus nerve or the chain of sympathetic ganglia are severed and not reconnected, such autonomic functions may be disrupted. The relevant fibres are smaller and presumably less easy to rejoin than the spinal cord. Is this likely to be another technical difficulty?
Grange over Sands, Cumbria, UK

From Luke Ferris
Helen Thomson's article on head transplants was exciting stuff. I generally feel the stir of a good debate to be quite healthy.

Surely though, in line with current transplant procedures, in which the new body part is featured in the title of the operation – heart, liver, kidney, etc – the proper name for Sergio Canavero's procedure should be a body transplant.
London, UK

Virtual performance

From Adrian Ellis
Jacob Aron's article on the new generation of virtual reality (VR) equipment focuses on its use in films or games (7 March, p 20). As the article notes, this can cause problems: in the case of games, the viewer can't see his or her controller, and in the case of films, he or she doesn't know what to focus on and the film equipment is hard to hide.

Why not instead use VR for live performances such as rock gigs, theatre showings, opera, sports games and so forth? In all those cases, the focus of attention is one particular area, and the presence of technicians and film equipment is a natural element. Additionally, in a performance attended by people through VR, the venue can be anywhere and the audience is almost limitless.

With microphones and headphones, the audience can cheer and applaud and hear those around them in the virtual venue cheering too, creating a very real atmosphere. It could transform live entertainment.
Hampton, Middlesex, UK

Dogged by doubt

From Bryn Glover
I confess to being less than convinced by Pat Shipman's explanation for the extinction of the Neanderthals (14 March, p 26).

She begins by describing the similarities between modern humans and Neanderthals, and the fact that we interbred, but her assertion that this was rare is not substantiated.

I would have thought that the modern genetic admixture of up to 5 per cent Neanderthal in those of non-African descent, which has survived in our gene pool without further input for tens of thousands of years, argues for more frequent encounters than rare ones.

Shipman goes on to propose that our ancestors developed their relationship with wolf-dogs in communities that coexisted alongside Neanderthals for thousands of years, and implies that the latter failed to observe, learn and mimic such activities.

Shipman tells us that all known wolf-dogs occur in human sites, but the absence of evidence at Neanderthal sites is surely not evidence of absence.

She may be right in declaring that humans kept their dogs and the secret of their training strictly to themselves, but I find it hard to believe they managed to do this successfully for millennia.
Glasshouses, Harrogate, UK

Migraine methods

From Elizabeth A. Carrey
I enjoyed Helen Phillips's recent article on the neurological changes in the brains of people who experience migraine (7 March, p 38).

About 35 years ago, when much less was known about the disorder, I attended a lecture in which an eminent US physician described the typical patient at his migraine clinic as a well-dressed woman, but did not mention any possible hormonal link with migraine attacks.

At the time, it was easy to infer a swipe at "uptight bored housewives", but perhaps his observation unwittingly supports the more recent work? My friend who has migraines dresses neatly, and cannot tolerate untidiness or background noise from radio or conversation – all could be signs of the mental distress caused by progressive structural changes to the brain. Being a bit uptight may be the result rather than the cause of a tendency to have repeated migraines.
Tiverton, Devon, UK

From Jan Horton
With a family history of migraineurs going back at least three generations, I was prone to motion sickness which was exacerbated by flickering lights, such as that caused by driving past tall trees. I suffered no headaches until I started using a contraceptive pill in the 1970s.

Frequent migraines occurred thereafter, even without the pill, until a ruptured ovarian cyst resulted in a hysterectomy in my mid-thirties. I haven't had a migraine in the 30 years since. Drastic, but totally effective.
West Launceston, Tasmania, Australia

Taking a dim view

From Ted Lovesey
David Hambling mentions that the UK Royal Navy developed a laser system to blind attacking pilots in the 1980s (7 March, p 44).

In fact, it was a Ministry of Defence establishment that put an experimental laser on HMS Hermes during the Falklands war but it was never used. I learned recently that naval commander Sandy Woodward did not like the idea and banned its use. Who said chivalry is dead?
Stoke Gabriel, Devon, UK

Self-policing cars

From Mike Tanner
Further to letters on self-driving cars (28 February, p 54), people only misbehave when they think they can get away with it, or if they don't care about the consequences. Self-driving cars will have cameras recording everything around them. Anyone breaking rules to disrupt traffic flow will be easily identified. If the consequences include being prohibited from using the network, you would think hard before either disrupting traffic or mistreating the cars.

People underestimate how motivated governments are to make these vehicles work. They can see the huge benefits to their health and welfare budgets if they can significantly reduce the cost of road accidents. Every dollar wasted on patching up people is another dollar they can put towards productive projects that improve society.
Auckland, New Zealand

Prime directive

From Liam O'Keeffe
Further to earlier letters, there is another reason why aliens may not have visited us (7 March, p 53). Any aliens advanced enough to cross the galaxy are likely to have strict rules about contaminating new worlds with their presence, much like scientists here have when visiting undisturbed places.

To such an advanced race we would appear primitive and barbaric, and far too dangerous to be exposed to their technology. Perhaps when we have achieved world peace, eliminated poverty and tamed climate change we will be permitted to meet these aliens.
Abinger Hammer, Surrey, UK

Siege breaking

From Pushkar Piggott
Victoria Esses's article on immigration is a breath of fresh air in a stale and depressing debate (7 March, p 26). She is more qualified than I to estimate the importance of rationality in this zone, so it is encouraging to hear her optimism for the possibilities in nations built on immigration. Yet I still find it hard to be optimistic here in Australia, where our prime minister and leading advocate of the siege mentality Esses describes is himself an immigrant.
Cygnet, Tasmania, Australia

Future prices

From Marc Bush
Calculations of the carbon footprint left by our consumer purchases tend to be complicated by how deep one gets into the supply chain.

What would be the carbon footprint of driving my rare-earth filled electric vehicle (14 February, p 35) 30 kilometres to the nearest store selling LED-grown greens (p 30), and paying for it with bitcoin (31 January, p 35)?
Morgan Hill, California, US

Syrian explosion

From Eric Kvaalen
The idea that global greenhouse emissions contributed to the Syrian civil war may be true, but this is quite a minor factor (7 March, p 6). A more important factor is the quadrupling of the Syrian population since 1960. With a population explosion like this, the country was bound to reach a point where agriculture was insufficient and unemployment would rise, even without global warming.
Les Essarts-le-Roi, France

For the record

- **Colossus was used to crack Nazi Germany's codes, but not Enigma (14 March, p 36), which was blown apart by the bombe machine at Bletchley Park.**
- **While NASA's probe Dawn is the first to orbit two different worlds (7 March, p 6), earlier spacecraft have visited multiple planets.**

Letters should be sent to:
Letters to the Editor, New Scientist,
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PAUL MCDEVITT

TERRY PRATCHETT was, Feedback guesses, the favourite fiction author of many of our readers. What can one say when the person who invented Death dies? The vicissitudes of weekly publication prevented our making a timely tribute to his encounter on 12 March with the anthropomorphic personification that he made a grim fictitious celebrity (and what other kind is there?) and that speaks in CAPITAL LETTERS.

We turn therefore for asynchronous inspiration to his book *Thief of Time*, so titled for the proverb that begins "procrastination is..." and the plot of which centres on the conceit that devices called "procrastinators" can stretch time as necessary or, for dramatic effect, unnecessarily. In this he remarked that "No other species anywhere in the world had invented boredom. Perhaps it was boredom, not intelligence, that had propelled them up the evolutionary ladder. Trolls and dwarfs had it, too, that strange ability to look at the universe and think 'Oh, the same as yesterday, how dull. I wonder what happens if I bang this rock on that head?'"

Or, indeed, "if I write that book"...

FEEDBACK thanks the University of Warwick, UK, for sending us its latest very serious Experts Directory. We particularly like the entry for Jack Cohen, a collaborator on several books with Ian Stewart and Terry Pratchett, listing expertise in: "Science fiction, reproductive biology, exotic pets, animal handling, aliens..."

A COLLEAGUE opens their post to find a spray container labelled "BetterAir". The accompanying press release announces "We all know that outdoor air quality causes massive health problems. What about indoor air? The same applies." So what is the solution? "You've heard of adding probiotics to your digestive system... now you can do the same with air... by injecting good probiotic bacteria into your indoor space." It promises "Solid scientific research... You can read more at better-air.org.uk" – but we don't find any peer-reviewed papers there, nor a clue what these bacteria are. We are not encouraged by the argument: "Disallowing breathing for more than 5 minutes is lethal. So, any solution that contributes to enhancement of the air we breathe should be seriously considered..."

The cap stays on that spray until we know more.

OOOH, aren't we cosmopolitan? For years now, Feedback has dozed in the undercroft of London's St Pancras station, waiting for trains to meetings in Brussels, Belgium. It was only when we went with a friend that we were alerted to a public-address announcement we'd been ignoring: "Property theft is a priority crime for your local British Transport Police Neighbourhood Policing Team." The friend was not at all reassured at the idea of theft done by qualified professionals.

IF there's anything we should learn from the internet, it's that not all crooks are fools. The latest example to come to our eyes was the collapse of a supposed bitcoin exchange in Hong Kong. That "supposed" is what we journalists call a "weasel word": it covers a certain vagueness in the ascertainable truth.

The largest bitcoin exchange, Mt. Gox, collapsed last year after "losing" bitcoins that at the time were worth several hundred million dollars. This February, the *South China Morning Post* reported a smaller loss at "MyCoin", which bereft investors are calling "a pyramid-style Ponzi scheme" – one in which new mugs' "investment" pays enough to earlier mugs to encourage more new mugs...

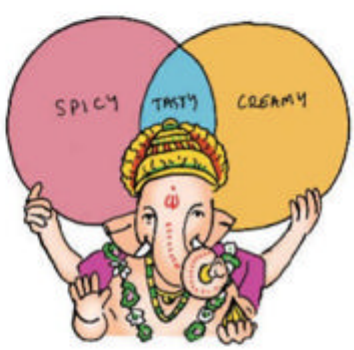
Selling bitcoins was not the scam; they didn't have any to sell, says Leonhard Weese, president of the Bitcoin Association of Hong Kong. Nor did they have a vast bank of computers making calculations to "mine" new bitcoins (31 January, p 35). They simply had a website that pretended to list bitcoin prices and sell contracts for bitcoin mining. They took in an estimated $29 million.

They did not issue any documents to prove the investments existed. They vanished, but six were soon arrested and may face the same kind of inconvenient incarceration that capped the career of Charles Ponzi.

NOW we have come across an even sharper scam: set up "Evolution", an online drugs marketplace, then disappear with $12 million of illegal bitcash. Allegedly.

FINALLY, Feedback thanks Craig Borland for sending an article on the chemistry of flavours in Indian cuisine from the website of *The Independent* newspaper, borrowed from *The Washington Post*'s Wonkblog.

What caught Craig's eye was writer Roberto Ferdman's observation that "Most of the compounds have scientific names". Our trouble is that we know exactly what Roberto means. Incomprehensible ones. Not worth troubling your little mind with. Indeed, Roberto presents Venn



diagrams mapping flavour overlaps, borrowed from a research paper, and each annotated with the advice to "Ignore the math symbols."

We can only hope that some young readers find this boring enough that, in the spirit of Terry Pratchett's observation, they resolve to bother their minds after all...

The poster that Jenny Narraway saw in a travel shop in the Netherlands promoted "nonstop return" tickets. That's even worse than going for the conference and not seeing the city at all...

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Spin doctors

Many science fiction writers have suggested designing a space station that spins to generate artificial gravity. Yet this idea has not been translated into reality, nor does it seem there are any plans to do so. Why not?

There are three main reasons this is not necessarily a good idea – stress on the structure, ease of docking, and sickness. I suggest rewatching the movie *2001: A Space Odyssey*, or at least the docking sequence, because it's very relevant to this.

You can grow a structure like the International Space Station (ISS) by sticking on new modules wherever it makes functional sense. In such a structure, which

"Docking with a spinning station means your feet experience gravity but your head is weightless"

is mostly free-drifting, a weak structural beam or brittle bolt is likely to be catastrophic. In a spinning station, failure of a critical stress-bearing component could lead to cascading failure and the entire thing flying apart. Adding modules to such a station would be trickier too. If you added something on one side, you would need to place something of equal mass on the opposite side.

Attaching to a dock at the centre of a spinning station would also be harder. Either the ship would have to spin at the same rate as the station, or you would need a docking hub that can spin down and up separately (which means more parts that can fail). If you had a station with a diameter of 4 metres, you'd need about 21 rotations per minute (rpm) to simulate Earth's gravity (*g*). But only your feet would experience 1 *g*: your head would be weightless, and you wouldn't be able to cope with moving. You could feel incredibly sick.

Some people could handle 5 rpm, and most can manage 3 rpm with time, but you would need a rotational speed of about 1 rpm for everyone to cope. To achieve 1 *g* at the rim of the spacecraft, where the astronauts would be, requires a ship 1.8 kilometres across. If you compromise by using 3 rpm, with a mere 0.5 *g* at the rim, that would still need a ship 200 metres across. The ISS is half that length. So for spinning to be useful, we would need stations that are bigger than anything we're willing to commit to right now.

Ron Dippold
San Diego, California, US

In the late 1960s, I went on a school visit to the Royal Aircraft Establishment in Farnborough, UK, which had a gravity simulation rig specifically to demonstrate the problems of spinning space stations. I remember sitting with three other students in the centrifuge, which had a concave table in the middle axis. As the spin increased, the effect on limb and head movement became extreme. Rolling a ball across the table gave the amusing effect of the ball appearing to return as the viewer moved to the opposite position. The bottom line of this demonstration was that a station's diameter would need to be more than 10 times the height of the astronauts to prevent nausea, and there would be no access to the station's connecting "spokes" for the same reason and also the lack of gravity.

Nick King
Croxley Green, Hertfordshire, UK

Sabre-toothed squirrel

This squirrel (see photo) appeared in a local garden during the recent fine weather. Can anyone explain the strange white appendages on its face?

This squirrel has overgrown incisors. Rodents and similar species have incisors that grow continuously, and if they do not meet accurately with the opposing tooth, they do not get worn down and will just keep on growing until they break off or the animal dies from starvation. Often, a tooth will grow out and round into the eye or face. Either way, the animal will have great difficulty in obtaining enough food to survive.

"Rodents and similar species have incisor teeth that grow continuously and must be worn down"

As a veterinary surgeon, I was called upon to cut off excess tooth growth in much-loved pet rabbits and guinea pigs – even the odd pet rat. It had to be redone every three or four months. The cause is usually some congenital defect, or traumatic injury to the jaw or tooth root that causes it to grow askew.

This one may have been hibernating and only recently emerged, because it would have had great difficulty obtaining enough food in the autumn to last the whole winter.

Christopher Robinson
Albert Park, Victoria, Australia

This week's question

SHAPE OF THINGS TO COME

The shape of comet 67P/Churyumov-Gerasimenko is intriguing and chaotic. What size do comets or asteroids need to be before they start to develop an orb-like shape, and what are the processes involved?

Malvina Moray
Doune, Perthshire, UK

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THE BAFFLING, TRIVIAL, CURIOUS, OR STRANGE . . .

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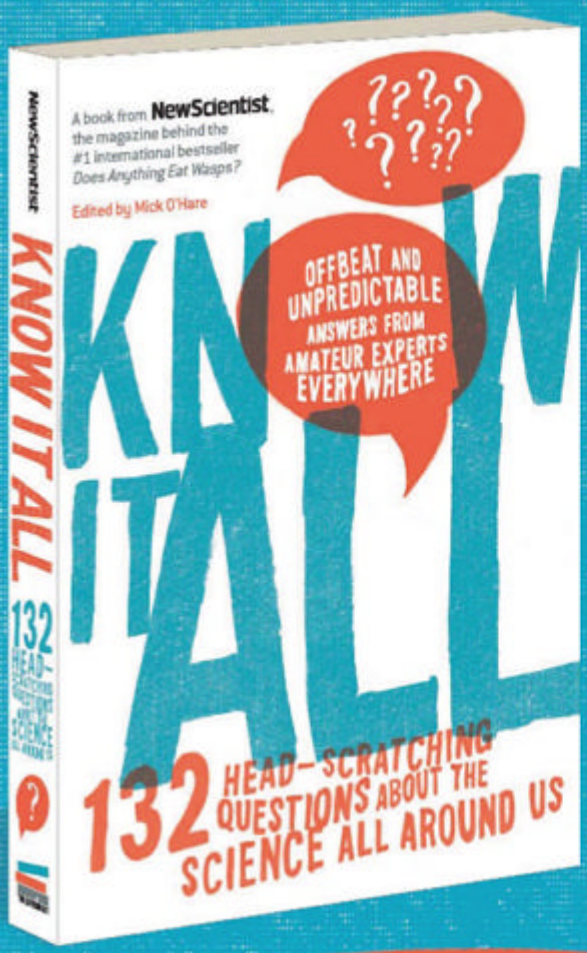

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